Barriers to Implementation of Tuberculosis Infection Control amongst South African Health Care Workers

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DECLARATION

MPH (Health systems) Mini-Dissertation

I, Oluwatoyin Adeleke, Student No. ADLOLU004 declare that the work this dissertation is based on my original work and where the work of others has been used (whether quoted verbatim, paraphrased or referred to) it has been attributed and acknowledged.

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Dedication

This study is dedicated to Health Care Workers delivering health services in high risk TB settings.

Abstract

HIV co-infection and drug resistance worsen the burden of Tuberculosis in South Africa. Infectious TB cases, often undiagnosed and untreated, are commonly found in health facilities increasing the likelihood of health-care associated TB. Health Care Workers (HCWs; and clients) are particularly at risk of TB infection in health care facilities; such risk characterises TB as a dual public health threat; first as a communicable disease and second as an occupational health hazard.

Tuberculosis infection control (TBIC) measures may reduce the risk of TB transmission in health care settings, yet HCWs face challenges implementing TBIC measures. There is a gap in operational research seeking to understand the barriers to TBIC implementation among HCWs. There is, therefore, an urgent need to generate qualitative data, using a behavioural and sociological approach that provides insight to TBIC implementation challenges among HCWs. This case study research explored the barriers to TBIC implementation among HCWs in Khayelitsha clinics.

Among professional and lay HCWs, data was collected by direct observation, interviews, focus group discussions and review of previous TBIC clinic assessment reports. The data was analysed using thematic analysis and interpretive analysis.

This minor dissertation is in four parts. The protocol (Part A) presents the concept note of the study and its methodology. A structured literature review (Part B) provides a background and broadly reviews previous research and findings on Tuberculosis infection control. The journal ready article (Part C) presents the study findings, while Part D presents the study tools and related resources (appendices).

Although most HCWs recognise the importance of TBIC in preventing health-care associated TB, they commonly believed that the TB transmission risk is only significant in clinic areas where known TB patients are found, and as such emphasise TBIC measures in those areas. Measures such as use of respirators and masks are mostly prioritized by HCWs ahead of administrative and environmental measures that are potentially more effective in reducing TB infection. Barriers to TBIC implementation identified include: inadequate HCW training on TBIC, a non-responsive compensation policy and the perception that a busy clinic schedule leaves no time for TBIC implementation. Resource availability, adequate human resources and leadership were further identified as enablers for TBIC implementation.

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PART A: Protocol

Health systems barriers to sustained implementation of TB infection control among health care workers in Khayelitsha health care facilities

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List of Acronyms

CDC: Centre for Disease Control

DOTS: Directly Observed Treatment Shortcourse

DOH: Department of Health

FGD: Focus Group Discussion

HATIP: HIV/AIDS in Treatment and Practice

HCF: Health Care Facility

HCWs: Health Care Workers

ICF: Intensified Case Finding

IPT: Isoniazid Preventive Treatment

ILO: International Labour Organisation

MDR-TB: Multi Drug Resistant Tuberculosis

NDOH: National Department of Health

SAHR: South African Health Review

TB: Tuberculosis

TB IC: Tuberculosis Infection Control

TB IPC: Tuberculosis Infection Prevention and Control

WHO: World Health Organisation

WHR: World Health Report

XDR-TB: Extensively Drug Resistant Tuberculosis

1.1 Introduction and Problem statement

1.1.1 Introduction

Tuberculosis (TB), including Multidrug Resistant TB (MDR-TB), threatens the most productive workforce age groups and is the second leading fatal infectious disease across the globe (World Economic Forum, 2008). South Africa has the fifth highest burden of TB disease worldwide further aggravated by HIV co-infection and drug resistance (Padayatchi et al., 2010). In addition to the fifth highest TB burden, South Africa has the highest number of people living with HIV/AIDS globally. Moreso, MDR-TB is the second biggest challenge facing the South African Health sector in relation to the prevention and control of epidemics according to the current (2010-2015) strategic plan (Harrison, 2009). Infection control is regarded as a critical preventive measure in settings with MDR/XDR-TB (Public Service Commission, 2010). Despite this huge burden of disease, low and middle-income countries still have limited resources to implement TB infection control as a preventive measure in health care facilities (Joshi et al., 2006). Where there is strong political will and commitment to resource availability for TB prevention, treatment and care, there is little attention paid to how Health Care Workers (HCWs) are being protected and managed as service delivery agents.

HCWs are at particularly high risk of *Mycobacterium tuberculosis (M. Tuberculosis)* infection (Corbett et al., 2007). Severe human resources crisis in global health and in HIV and TB services is worsened by health-care associated TB (Basu et al., 2007). The spread of drug resistant TB to patients and HCWs can be attributed to poor infection control practice in health facilities (Harries et al., 1999).

Joint World Health Organization (WHO) and International Labour Organisation (ILO) guidelines for improving access and care for TB and HIV (WHO/ILO, 2010) recognise infection control as an essential component of occupational health services; this forms a basis for health risk management to protect HCWs and patients in health care facilities. Congregate hospital settings with inadequate infection control facilities have recorded an increase in transmission of TB including multi-drug resistant and extensively drug resistant TB (XDR-TB) in South Africa (Basu et al., 2007; Bamford& Taljaard, 2010). Prolonged patient waiting period and delayed diagnosis also contribute to the alarming rate of health-care associated TB

(Wu et al., 2007; Bock et al., 2007). In a review of *M. Tuberculosis* infection and TB disease in HCWs in low-income countries, the median annual incidence of occupationally acquired TB was 5.8% (Joshi et al., 2006; Shenoi et al., 2010). A recent household study in Khayelitsha revealed that nearly everyone who participated in the study knew at least one person who contracted TB in the past or is undergoing treatment (Abney, 2010). This high incidence rate reveals the risk of TB transmission among HCWs and patients in care facilities and calls for urgent attention through operational research.

1.1.2 Problem Statement

Tuberculosis has been identified as a major health problem facing the Western Cape Province with an incidence rate of over 900 per 100,000 in 2006 (Department of Health, 2006; Bamford & Taljaard, 2010). Similarly, Khayelitsha, the largest township in South Africa's Western Cape Province, has one of the highest TB (including MDR-TB& XDR-TB) and HIV co-infection rates in the country and globally (WHO, 2009). In 2008, the TB case notification rate in Khayelitsha was high at 1,158 per 100,000 per year. Similarly, 74% of DR-TB cases diagnosed in Khayelitsha were also HIV-infected in 2008 (MSF, 2009; Cox et al., 2010).

Undiagnosed and untreated TB cases are commonly found in waiting rooms of health facilities (Heysell et al., 2011; Shenoi et al., 2010; WHO 1999) thereby increasing the likelihood of health-care associated TB (Bock et al., 2007). In spite of a well-established Directly Observed Treatment Short-course (DOTS) based TB program, a study revealed an increasingly low TB case finding that misses 63% cases of pulmonary TB among community adults in South Africa (Wood et al, 2007). Such poor TB diagnostic service underlines the need for infection control. Infection control practices aimed at reducing TB transmission in health facilities are majorly dependent on HCWs. Invariably, HCWs are an essential part of the health system. However, shortage of trained HCWs and de-motivated staff are barriers to achieving TB infection control (TBIC) targets (USAID/Stop TB 2010).

Anecdotally, at a clinical forum on TBIC in Cape Town, HCWs (including those from Khayelitsha clinics) verbally acknowledged the importance of TBIC in preventing TB transmission in health facilities (Anonymous, personal communication, 2011).

However, HCWs identified barriers to TBIC implementation as resource constraints and lack of systems support leading to an extreme reliance on personal protection. Meanwhile, personal protection measures being solely relied upon (i.e. respirators) was described as 'uncomfortable' causing major communication barrier between HCWs and patients. Overall, as a result of work overload experienced by HCWs in health care facilities, TBIC is perceived as a burden. This research aims to further explore and explain barriers to implementation of TBIC among HCWs in Khayelitsha clinics.

1.2 Background to Research

1.2.1 Tuberculosis

Tuberculosis is an airborne contagious infectious disease caused by *Mycobacterium tuberculosis*. People who have TB disease can release invisible tiny droplet nuclei containing *M. tuberculosis* into the air by coughing. Droplet nuclei can remain airborne in room air for many hours, until they are removed by natural or mechanical ventilation (WHO, 1999).

> ''To spread, there must be a source, a person with TB disease who produces *M. tuberculosis*, and an exposed person to inhale droplet nuclei containing the bacteria. Although TB is not usually spread by brief contact, anyone who shares air with a person with TB disease of the lungs in an infectious stage is at risk. A person who inhales one or more of the droplet nuclei can become infected with *M. tuberculosis''* (WHO, 1999).

1.2.2 Health-care associated Tuberculosis

Health-care associated infection (including nosocomial) can be introduced and transmitted by staff or patients in health care facilities (Mehtar, 2010). Health-care associated infections pose a major threat to prevention and control of infections in public health. An example of health-care associated infections that are of public health concern is TB.

1.2.3 Tuberculosis Infection Control (TBIC)

TB Infection Control (TBIC) is a 'combination of measures aimed at minimizing the risk of TB transmission within populations' (Mehtar, 2010). Infection Prevention and control-(IPC; including TBIC) is an internationally recognised and legislated prevention strategy. Provisions for IPC in South Africa are documented in Health and Safety at Work Act, Occupational Health Act, Public Health Act, Constitutional law and WHO recommendations

(Mehtar, 2010). Studies reveal continually reduced incidence of TB during the first five years of highly active anti-retroviral therapy –HAART (Lawn et al., 2005, Currie et al., 2003, William et al., 2003). However, a systematic review suggests the use of secondary TB prevention strategies such as the three I's (including infection control) alongside treatment to further reduce TB burden (Corbett et al., 2006).

The three I's (3I's) are key public health strategies recommended by the World Health Organization to reduce the impact of TB particularly among people living with HIV/AIDS. The three I's strategies are: Isoniazid Preventive Treatment (IPT), Intensified Case Finding (ICF) for active TB and infection control (WHO, 2008). TBIC, the third recommended strategy aims to protect vulnerable patients and clinic attendees in health facilities, HCWs, the community and other congregate settings from getting TB. With the increase in the number of drug-susceptible and drug-resistant TB infections, infection control (IC) remains a viable prevention tool that needs to be maximized to avert TB-related morbidities and mortalities. Although South Africa has adopted the stop TB 3I's strategy, there remains an inadequate capacity to deliver on many of the urgently needed health-care interventions including TB infection control (Karim et al., 2009). One of the key requirements for TBIC is health system strengthening (Shenoi et al., 2010). Meanwhile, TBIC practices are majorly dependent on sustained implementation by health care workers (Shenoi et al., 2010). Despite the fact that South African health system is being integrated to deliver comprehensive health care services at district levels, failures in stewardship, weak management are said to often result in poor implementation of policies such as TBIC (Coovadia et al., 2009).

There are challenges in implementing infection control measures, particularly ensuring the support of HCWs within Khayelitsha health care facilities. The World Health Organization provided an ideal template (Appendix 4.1) for implementing TBIC within health facilities. According to the WHO template, TBIC comprises a hierarchy of three categories of control measures that ought to be implemented simultaneously to reduce the risk of TB infection control in health care facilities. The three measures of TBIC are administrative control, environmental control and personal protection.

Administrative control

This is the first level of TB infection control aimed at reducing the spread of TB within health facilities. This level of TBIC control encompasses the role of co-ordination, supervision and communication in service delivery. This measure of control is described as the first line of defence against TB transmission within health facilities (Bock et al., 2007). The most important administrative infection control measure is to promptly identify people with TB symptoms (triage), place them on treatment and minimize time spent in health facilities. 'Appendix 4.1' outlines details of other administrative control measures according to international guidelines (WHO, 2009) while 'Appendix 4.2' depicts measures already in place in Khayelitsha clinics (HATIP, 2010). As front-line implementers of TBIC, health care workers are responsible for promptly identifying TB suspects (triage), separate suspects from other patients, promptly attend to them and minimize time spent in facilities. As part of administrative control measures, paper masks serves the same purpose as cough hygiene measures as it aims to reduce the concentration of infectious particles in the air (Mehtar, 2010). This requires oversight of HCWs to ensure that all patients wear paper masks appropriately. However the health system also plays a vital (management) role in the timely supply and logistics of respirators and paper masks.

A study that assessed TBIC in resource-limited setting in rural South Africa district hospitals found that despite a high level of information among health care workers, motivation and behavioural skills needs to be improved through life-long training (Kanjee et al., 2008). The study identified several 'deficits' in administrative measures such as lack of Infection control policy, poor TB screening process, inadequate separation of TB suspects and inconsistent use of cough hygiene. The health system is thus required to provide resources as well as oversight and leadership in implementing TBIC administrative measures. Training and re-training health care workers, establishing an infection control committee and drafting a facility based infection control plan (See Appendix 4.1 and 4.2) require a level of health system support for sustained implementation.

Environmental control

Environmental control (otherwise known as engineering control) is the second level of TBIC in health facilities (WHO, 2009). Environmental control measure requires the establishment of administrative control to ensure proper operation and sustainability of environmental

controls (Bock et al., 2007). This entails ensuring adequate ventilation in areas where there is likely to be a high TB transmission risk. This can be done through natural or mechanical ventilation or a mix of both. Natural ventilation can be improved by opening windows and doors leading outside, installing wind-driven air extractor turbines (whirlybirds) in indoor waiting areas, corridors and consultation rooms to increase natural ventilation. Environmental controls also include the provision of sputum collection booths outside out-patient waiting rooms and consulting areas but still within the premises of health facilities (WHO, 2009; HATIP, 2010). Appendix '4.1' and '4.2' provide more details on internationally recommended and operational environmental controls in Khayelitsha clinics respectively.

Similar to administrative control, the behaviour of HCWs can influence the sustained implementation of environmental control measures. Keeping windows open, retaining the use of rooms for intended purposes, monitoring the correct and consistent use of ventilation equipment, ensuring maintenance of installed whirly birds are all dependent on the behaviour of HCWs as a functional part of the health system. One of the 'deficits' in environmental control measure was identified as inconsistent natural ventilation during winter months which is not unlikely in Khayelitsha health facilities (Kanjee et al., 2008). Essentially, environmental controls require a high level of health system support, resource allocation, financial commitment as well as health care worker's support to implement administrative control measures: a basis for environmental control.

Personal protection

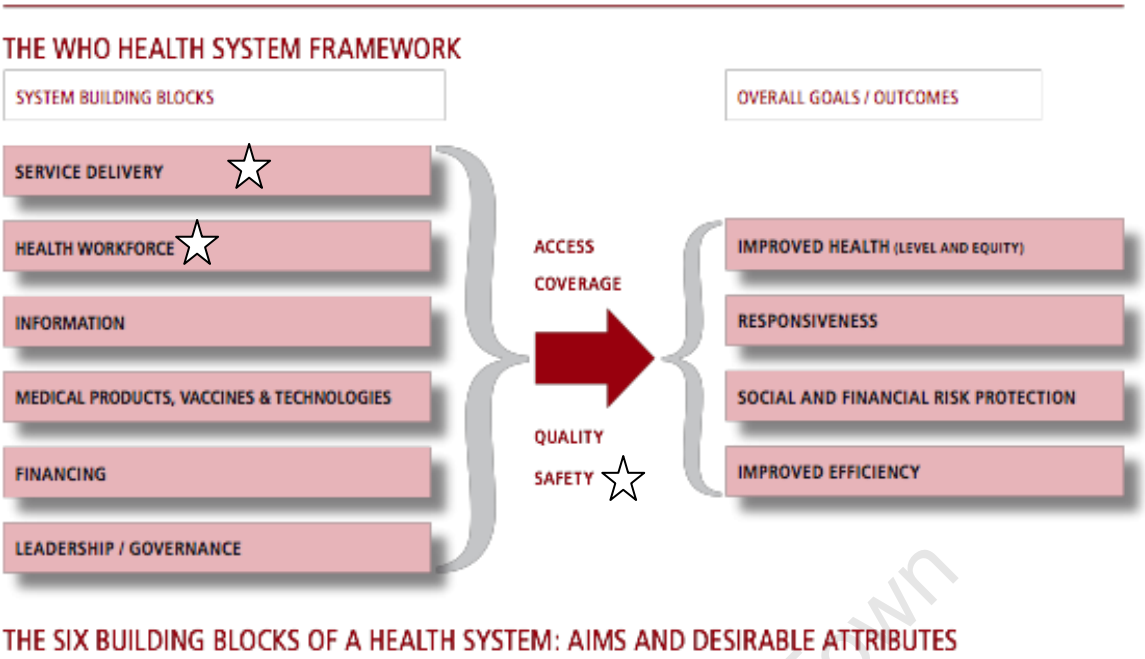
The third and last level of infection control is directly for protection of HCWs and this includes the use of N95 respirators by all clinic staff (HATIP, 2010). Respirators protect HCWs who interact closely with patients, from TB infection in health care facilities. Ideally, N95 respirators would be fit-tested for each HCW (Mehtar, 2010) but this depends on the willingness of the HCW to ensure proper fit if at all it is worn. The 'N 95' tag for respirators denotes the certified efficacy of its filter (Fenelly, 1998). Personal protection measure requires compliance of health care workers to correctly consistently use respirators. Stock out and non-availability of such resources can limit health care worker's performance and increase the risk of health-care associated TB.

On the whole, TBIC relies on health system support demonstrated in the provision of adequate administrative and environmental control measures that are available, accessible and acceptable to health care workers (Fenelly, 1998). A study of health care workers in isolation of the health system in which they operate is likely to generate findings that may not be useful to health facilities. The health system can be easily linked to HCWs behaviour if such key actors are studied within an environment where TBIC implementation operates/ is expected to operate.

1.2.4 Health system

A health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health (WHO, 2007). Although the South African Health system is being integrated to deliver comprehensive health services including TB/HIV, inadequate stewardship and management often leads to poor implementation of policies (Coovadia et al., 2009). A study evaluating Cuba's successful strategy for childhood TB control over a period of 10 years(1995-2005) revealed the crucial role of health systems in TB control (Abreu et al, 2011). Improvements recorded in the 'work and systematic training' of health workers at primary health care level contributed to the success story of Cuba TB control (Abreu et al, 2011).

Figure '1' below shows the WHO framework of the health system, which depicts 'health workforce' as an essential building block of a functional health system. It is important to note the intermediary 'safety' component of the framework (Fig 1) that links input (system building blocks) to desired outcomes (overall goals). TB infection control is one of the safety measures adopted by the health system to reduce tuberculosis infection within health care facilities. Safety is one of the factors that determine the quality of care received in health facilities whether or not the intended outcome of improved health will be achieved.



☆ *Represents specific variables within the health systems framework related to the study.*

Figure 1: WHO Health system Framework (WHO, 2007)

Shortage of HCWs has been a major barrier to health systems strengthening particularly in low and middle income countries (Haaland& Vlassoff, 2001; World Health Report, 2010).

Health Care Clinics

The South African Health system delivers primary health care services to majority of the populace through clinics. District- level clinics are structured as stand-alone buildings within communities where curative and preventive health services (including TB/HIV) are delivered to the public (Mehtar, 2010). Ventilation in waiting areas, consulting rooms and other parts of the clinic is critical to reducing health-care associated infections such as tuberculosis.

Brief Description of Khayelitsha: study location

Khayelitsha is a peri-urban township located 40 kilometres from Cape Town. With a growing population of over 500,000(MSF, 2011); it is popularly known as the largest and fastest growing township in Western Cape. Characterised by a high level of poverty and unemployment, this township houses most migrants from the Eastern Cape and other countries seeking employment in Cape Town. There are eleven (11) primary health care

facilities in Khayelitsha: community health centres (2), combined facilities (2), clinics (4), youth centres (2) and male partnership clinic (1).

1.2.5 Health Care Workers

Health Care Workers and TB Infection Control

Health Care Workers are frontline workers as well as TBIC policy implementers in health facilities. HCWs are often refered to as 'street-level bureaucrats' due to their direct interaction with users of health services. They also exercise a level of discretion and autonomy over health services by interpreting health policies such as TBIC and adapting it to the local setting in order to cope with complex realities.

The behaviour of HCWs is often shaped by the nature of health services being delivered as well as the environment in which they operate. In response to daily challenges and complex realities encountered in health service delivery (Rowe et al., 2005), HCWs tend to develop routines and simplified ways to cope with work overload and manage stress (Erasmus, 2011).

1.2.6 Gaps in Literature

There remains a dearth of information regarding specific health system barriers to sustained implementation of TBIC within health facilities. According to WHO (2010); one of the knowledge gaps identified in TBIC research is 'lack of operational models' to implement infection control in health care facilities. This study will build on existing literature to further explore and explain barriers to implementation of TBIC among health care workers in Khayelitsha health facilities.

2.0 Research questions, objectives and Justification

2.1 Research Questions

2.1.1 Main Question

What are the health system enablers/barriers to implementation of infection control measures among HCWs in Khayelitsha TB/HIV clinics?

2.1.2 Subsidiary questions

1. What 'systems support' (training, policy, resource availability) currently exist within health facilities in Khayelitsha to assist health care workers in implementing administrative and environmental TBIC measures?
2. What motivates health care workers' performance (i.e availability, responsiveness and productivity, financial or non-financial incentives) to implement TBIC within the existing South Africa's health care system (District level clinics)?

2.2 Study objective

The main objective of this qualitative study is to explore and explain health systems barriers to implementation of TBIC among health care workers in Khayelitsha health facilities.

2.2.1 Specific objectives

1. To identify barriers to implementation of administrative, environmental and personal protection measures among health workers in Khayelitsha
2. To explore the nature of health systems support available in health facilities for sustained implementation of TBIC among health workers in Khayelitsha
3. To explore and explain motivational factors that predict sustained implementation of TB infection control measures among health care workers.

2.3 Study benefits

The outcome of this research can inform policies on infection control. Beyond tuberculosis control program, this health systems research will provide recommendations on staff motivation and sustained policy implementation. This research will also provide recommendations to health managers on facilities needed to support HCWs to implement TBIC as well as suggest key strategies to improving service delivery within health facilities.

3. Methods

3.1 Conceptual Framework

A conceptual framework gives an ideological position to qualitative research (Holliday, 2007). The conceptual framework in this proposal shows the key elements of health systems research and how it relates to TB infection control practices among health workers. Adapted from Franco et al., 2002, this conceptual framework identifies and links variables of interest such as motivation, performance, systems support, resource availability and outcomes.

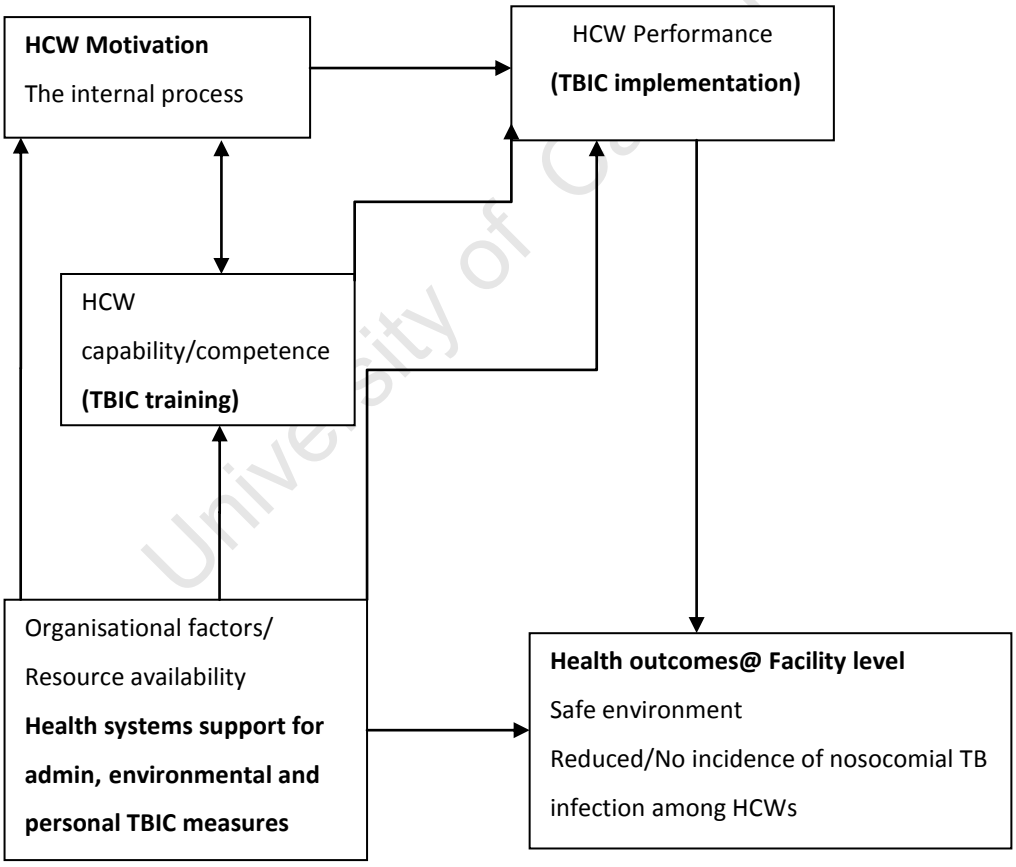


Figure 2: Work Motivation in the organisational context (Franco et al., 2002)

Figure two above shows the inter-relationships between health worker motivation, performance, competence/training, health system support/resource availability and health outcome as well as experience of HCWs in TBIC implementation. Two clinics that differ in size, resource availability, HCWs training, capability and motivation are being considered. Key questions that reflect the ideological position of the researcher are as follows: What are the enablers or barriers to implementation of TBIC in these two clinics? Are there similarities? Are there differences? What are the reasons for identified similarities or differences? How can such similarities or differences be explained from this ideological position? Are there emerging issues from research, such as new variables other than those depicted in *Figure 2* above? All these questions are to be explored and explained using a case study research methodology.

3.2 Study design

This study will predominantly utilize qualitative research methods.

Case study: Case study is a strategy for doing research that involves an 'empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence' (Yin, 2009; Robson, 2002). This case study is instrumental to exploring TBIC practice among HCWs (Stake, 1995). Context refers to the 'broad picture of relevant factors, relationships and structures in which case(s) are located (Rule and John 2011). The South African district health system is the context where TBIC practice will be examined. Although this case study research examines health system context, other personal, historical, social or political context may emerge (Stake, 1995). A multiple case study approach will be adopted where cases (health workers) can be studied within the real life context (clinics) and health system barriers to TBIC practices can be explored. A case study research is appropriate for this operational research whereby a medical practice such as tuberculosis infection control among health care workers is being explored. The health care worker's availability, performance, motivation or de-motivation and its relation to the health system is best observed and explained in context. Moreso, data is said to be meaningful when interconnected in systems framework (Holiday, 2009). This case study methodology does not refer to the health system as a mere location such as Khayelitsha clinic; rather, it recognises the interactions of actors (HCWs and patients), safety in service delivery (TBIC) as well as resources available (medical supplies, infrastructure). The case study approach regards the

clinic as a study site where such key interactions can be practically explored. An advantage of the case study approach is that it promotes knowledge translation being a phenomenological study. The content is studied in relation to real life context and recommendations are more applicable to each study site. Furthermore, the study design is an exploratory and explanatory multiple embedded case study.

Exploratory: the study aims to identify health system barriers to sustained implementation of TBIC. Sissolak et al., (2011) identified 'weak health systems' as a barrier to implementation of TB infection prevention and control in hospital settings. This study seeks to further probe the nature of health systems in health facilities as it relates to the implementation of TBIC. This exploratory case study aims to unveil the challenges of TBIC practice: an underground context as perceived by HCWs (Rule and John, 2011).

Explanatory: The study seeks to understand the compliance and non-compliance phenomenon among clinics cases using a conceptual framework ('workforce motivation framework'). This compliance and non-compliance phenomenon will be interpreted as enablers or barriers of TBIC implementation among HCWs based on the 'workforce motivation' ideology (Franco et al., 2002).

Multiple-embedded: Two clinics (cases) are being investigated with the aim of comparing cases using literal replication/cross case analysis of two similar cases (clinics). Health care workers will be observed and interviewed (as sub-units) to enrich the quality of data. Though the study focuses on exploring HCWs TBIC practice as a whole, it may be useful to observe and analyse some individual HCW motivation or de-motivation in TBIC practice. Because data collection is further disaggregated into sub-units of individual HCWs within both clinics qualifies the study to be a multiple embedded case study. It is important to note that the thinking behind using multi-embedded approach is not to generate statistically representative sample, but to enrich the quality of data presented in analysis (Robson, 2002).
Study sites are being limited to two clinics considering feasibility of data collection (one researcher) and time constraints given the academic purpose of the research.

3.3 Study population

The study population will be health care workers within two Khayelitsha clinics and include (but not limited to) doctors, nurses, nursing attendants, cleaners. Paid and unpaid staff, professional and lay health workers will also be included in the study population. This is because health care workers usually consist of paid and unpaid workers, lay and professional cadres within study sites (WHO, 2007); therefore, the various cadres of health workers should be represented in the study population to enhance internal study validity.

3.4 Sampling

This research will adopt a multi-stage sampling technique using purposive sampling to select sites (clinics) and convenience sampling in selecting HCWs. The study sites are two primary health care facilities.

3.4.1 Purposive sampling of clinics

A list of TB/HIV clinics will be obtained from MSF office in Site B, Khayelitsha. Initially, two clinics were to be selected based on size (one large and one small clinic determined by number of patients and daily workload), clinic design, number of HCWs, consultation with the city of Cape Town health managers. After due consultation with the Khayelitsha district health manager, we were advised to select two large clinics because one of the proposed clinics will be undergoing rennovation and we likely to find more HCWs in large clinics based on the multi-embedded case study design. The researcher will conduct site visits to clinics to enable sampling of clinics eligible for research using inclusion and exclusion criteria.

3.4.2 Convenience sampling of Health Care Workers within clinics

Due to the busy nature of health facilities, time constraints and inability to predetermine when a certain staff will be available for interview, convenience sampling is the most appropriate in selecting HCWs within each clinic. A maximum of twenty health care workers will be sampled per clinic and a minimum of ten health care workers. An estimate of HCWs to be sampled was given as 20 per clinic with a sample size of 40 out of 69 HCWs in both clinics.

Inclusion criteria

Due to the patient workload in clinics (Anonymous, personal communication, 2011), HCWs will be selected based on:

-Availability preferably during lunch break or as indicated by interviewee

-Understands and can speak English

-Works as a HCW in selected clinic

Exclusion Criteria

HCWs that do not understand and cannot speak English will be excluded from the study. This is due to resource constraints and non-availability a research assistant and interpreter.

3.5 Data collection

Due to the nature of case study research where multiple sources of evidence can be used to validate data; semi-structured interviews, key informant interviews, focus group discussion and observations were used to collect data. The principal researcher (studying for a Masters in public health) will collect data in both clinics.

3.5.1 Semi-Structured Interviews

Semi-structured interviews are often used to obtain points of view, reflections and observations of people who have specialized knowledge, a particular status or position (Robson, 2002). In this context, professional health care workers including doctors, nurses, pharmacists and laboratory technicians working in selected clinics will participate in semi-structured interviews (Table 1). A minimum of ten semi-structured interviews will be conducted in each clinic comprising three doctors, three nurses, two laboratory technicians and two nursing attendants. Due to the busy schedule in clinics, respondents will be selected using convenience sampling based on availability.

3.5.2 Key Informant Interviews

Key informant interviews can provide in-depth information the study seeks to explore such as health system barriers to sustained implementation of TBIC (Table 1). This 'health systems angle' from a facility manager perspective can complement provider perspective provided by

semi-structured interviews and focus groups. Key informants are one of the gatekeepers who are not only conversant with daily clinic activities but also responsible for ensuring the daily operation of health care facility. Key informants are facility managers or head of clinic that will be purposefully selected. Two key informants will be selected per clinic. Where there are more than two facility managers, convenience sampling will be used based on availability and designation most related to thematic area of study -TB infection control.

3.5.3 Focus Group Discussions

Focus group discussions (FGD) provide insight on a particular issue by directly interviewing a group of people directly affected by the issue (Robson, 2002) while observing group dynamics (Rule and John, 2011). FGD can generate useful data for exploring and explaining health system barriers to TBIC implementation among nursing attendants, cleaners and other lay health care workers (Table 1). The focus here refers to 'lay HCWs' who support professional HCWs in health service delivery. There will be no segregation by sex or age at the point of data collection because the study focus is likely not to be sensitive to sex or age difference. Unlike professional HCWs, lay health workers are more likely to be available as a 'group' during several breaks from adhoc duties such as cleaning of sputum booths. Shared experiences of lay HCWs is best captured in a group where discussion is stimulated around the issue and researcher is likely to record health system barriers participants are most reactive to with reasons unlike interviews where 'group dynamics' is missing. Using convenience sampling technique, a minimum of eight (8) lay HCWs and maximum of ten (10) will be recruited to participate in FGDs. Prior to recruitment, lay HCWs will be consulted by researcher about preferred time for discussion.

3.5.4 Direct Observation

This study is associated with a health practice (TBIC), therefore observing how HCWs carry out Infection control measures will generate vivid scenarios (such as behaviour of HCWs) complementary to FGDs and interviews. An observation grid (Appendix 2) outlining observable measures of administrative, environmental controls and personal protection. The researcher will spend five (5) days per clinic observing daily TBIC practices and permission will be sought from facility managers prior to observing. Although Hawthorne effect

(Robson, 2002) is a likely limitation of direct observation, it is less intrusive than participant observation. Observed TBIC practices will be compared to HCWs responses in interviews and FGDs to check for consistencies that may be biased by Hawthorne effect. Floor plans of the TB section per clinic (which describes clinic environment) will be sketched from direct observation as a key resource in reporting study findings.

Table 1: Summary of Data collection plan

Method	**Number per clinic**	**Respondent(s)**
Semi-structured interviews (see appendix 1.1)	10 per clinic	Doctors, Nurses, Laboratory Technician, Pharmacists(professional HCWs)
Key Informant interviews (see appendix 1.2)	2 per clinic	Head of Clinic, management staff
Focus Group discussions(see appendix 1.3)	1 per clinic	Lay health workers (nursing attendants, cleaners…)
Direct observation (see appendix 2)	5 working days per clinic	Researcher to use observation grid to record events

3.5.6 Instruments for data collection

Note Taking

The researcher will take notes during data collection that will be compared to transcribed notes from audio recording. Note taking requires writing materials such as note pads, biros and highlighters.

Audio recording

Both interviews and Focus Group Discussions will be audio recorded with prior consent from participants. Audio recording will enable the researcher to capture all that is being said by

respondent(s). Note taking may be challenging depending on how fast respondents speak. Note-taking and audio recording are complementary. A digital audio recorder, writing pads and biros will be needed for audio recording and transcription. Consent will be sought prior to recording and tapes will be destroyed after transcription (See appendix 5).

Interview and Focus Group Guides

Guidelines for semi-structured interviews (Appendix 1.1), key informant interviews (Appendix 1.2) and focus group discussions (Appendix 1.3) have been developed using WHO guideline for TBIC implementation in Health care facilities (TBCTA, 2009).

Observation Grid

A checklist for observation of health systems support/resource availability per site has also been developed using CDC/WHO guidelines (TBCTA, 2009; See Appendix 2).

3.6 Data Analyses

The reasoning process for data analysis will be both deductive (using organizational theory to analyse data) and inductive (deriving explanations from data collected). Data collection and analysis will run concurrently. Data will be analysed using the thematic analysis, interpretive analysis and literal replication.

Transcription: Audio-recorded data collected from interviews and focus groups will be transcribed by the researcher and tapes destroyed after transcription.

Thematic analysis: Note-based and transcribed audio-recorded data will be grouped into themes of similarities and differences. A thematic codebook will be generated based on HCWs responses on identified barriers (or enablers) to TBIC implementation, training, motivation and de-motivation factors, resource availability, competence, responsiveness and productivity, financial or non-financial incentives. Data from interviews and FGDs will be coded and analysed manually (Holiday, 2009).

Interpretive analysis: Using health workforce conceptual framework, coded themes from thematic analysis will be related to observations and other key data sources and interpreted in the context of each clinic. The observation grid will be manually analysed using interpretive

analysis in relation to data generated from FGDs and interviews. Interpretive analysis will be used to explain barriers to sustained implementation of TBIC practices among HCWs in selected clinic sites.

Literal replication: The health workforce framework will be used to analyse results within and between study sites (clinics). Similarities will be drawn per cases within each study sites and cases will then be compared and negative cases reported. Coded data will be compared per clinic; similarities differences will be analysed using literal replication. At this point, explored data on identified enablers or barriers to TBIC implementation will be analysed and an explanation sought for identified similarities and differences in relation to the conceptual framework *(Figure 2).*

3.7 Validity and reliability

In case study research (like many qualitative research), validity is negotiated between the reader of study findings and the researcher (Robson, 2002; Yin, 2009). However, to improve validity of the study the following strategies have been considered and included in the study design:

Use of conceptual framework ('workforce motivation'): The use of conceptual framework is a pivot to research purpose. The framework also links objectives and depicts relationships between these objectives. This gives direction to the research and suggests validity and reliability (Yin, 2009).

Multiple case study design: The study involves than one site (clinic/health facility) which leaves room for comparability. Moreso, the sites are selected based on different characteristics in based on size (one large and one small clinic determined by number of patients and daily workload), clinic design and number of HCWs.

Triangulation: Multiple sources of data were explored through document review of prior TBIC assessment in both clinics to cross-validate results.

Member checking of responses: After every interview and discussion, researcher will seek to clarify responses from HCWs on site by summarizing written notes and asking participants if their responses were well represented in words. Distortions and research bias can be limited through member checking (Yin, 2009). Supervisors may send the researcher to clarify responses on site based on submitted notes, audio records or transcripts.

Negative case analysis: This refers to the researcher's non-bias and transparency in interpreting findings (Yin, 2009). Although the study seeks to identify health system barriers to TBIC implementation, there is a possibility of discovering enablers to implementation and this will be analysed in the study findings as well. To prevent researcher bias, the positive and negative aspects of the research will be explored and duly reported. In other words, although the research title suggests an interest in health systems 'barriers', it is not unlikely to find health systems 'enablers' to TBIC implementation; such findings will be analysed as negative case findings to minimize researcher bias.

Peer de-briefing and support: Supervisors will be de-briefed through email consultation (every two weeks) and 'report back sessions' monthly. The selection of supervisor and co-supervisor for this study was preceeded by a scrutiny of academic status, qualifications, relevant area of specialization ensured by the School of public health and family medicine, University of Cape Town. The supervisors' experience in qualitative research and thematic program area (TBIC and health risk management) will not only enrich the study but also contribute to study validity.

Audit trail: Research protocol, transcripts, notes, observation report will be documented and archived in researcher's custody before, during and after data collection for easy retrieval. Apart from the researcher, supervisors and external examiners will have access to archived documents during feedback sessions or on request.

Reflexivity: Since study validity is negotiated between the reader and researcher (Yin, 2009), researcher's background, values and stance will be clearly stated to enable readers make their own judgement about the case study validity. A brief background of the researcher (including values and stance as it relates to study) will be clearly stated in the write up to enable readers make their judgement on study validity.

3.8 Time Frame, Budget and Dissemination Plan

The anticipated time frame for the study is 11 months; between May 2011 till March 2012. Data collection and analysis will be done concurrently based on the flexible research design. *Table 2* shows details of planned activities within the eleven-month period of the study.

Dissemination

Findings will be disseminated to stakeholders including MSF and Khayelitsha health representatives at the district level infection control committee monthly meeting in Khayelitsha at the end of the study and other relevant forums by the researcher, supervisor(s) and/or both. A journal article will also be developed from the study findings and submitted for publication both locally and internationally in a peer-reviewed journal.

Table 2: Shows Time frame for study

Date / **Activity**	May 2011	Jun 2011	Jul 2011	Aug 2011	Sep 2011	Oct 2011	Nov 2011	Dec 2011	Jan 2012	Feb 2012	Mar 2012
Literature review											
Ethics Approval											
De-briefing to Supervisors											
Data collection											
Data Analysis											
Write up											
Submission											

Budget Summary

A total amount required for research is three thousand, one hundred and ninety rands (R3190) only. *Table 3* presents the budget items for this study.

Table 3: Shows a summary of budget for study

S/N	Line Item	Unit Cost	Total cost
1.	**Transport (30 working days)	R50	R1500
2.	Refreshment(40 participants)	R25	R1000
3.	Note books(6)	R20	R120
4.	Biros(4)	R10	R40
5.	Batteries for Midget (6 pairs)	R30	R180
6.	Recording tape for midget(6)	R50	R300
7.	Highlighters(2)	R25	R50
Total			**R3190**

***Transport indicated is inter-transport from Cape Town to Khayelitsha. MSF will provide transport within Khayelitsha study sites.*

3.9 Ethical consideration

The study protocol will be sent to UCT ethics committee for approval before the study commences. In order to conduct research in clinics, the research team (Principal investigator and supervisors) will seek approval from the city of Cape Town research committee. Pre-requisite research forms will be duly completed once UCT ethical approval is granted. Research will not commence until approval is granted by UCT ethics committee and city of Cape Town research committee.

Consent forms

This study acknowledges the importance of seeking informed consent as a pre-requisite for HCW participation in the study. Informed consent will be sought from study participants using consent forms in line with Helsinki Declaration of 2008 (Joubert and Ehrlich, 2007) (See Appendix 3).

Remuneration to participants

HCWs who participate in this research will be served light refreshment in the course of the interview. Due to possible workload in clinics, HCWs are likely to participate in research during lunch breaks.

Potential benefits:

To Health System/health facility: This research will identify health system barriers to implementation of TBIC in health facilities; removing such barriers will contribute to improvement of the health system. This research will also provide practical recommendations to stakeholders on developing a context-specific TB infection control policy. This research may also suggest strategies to improve health worker performance as an integral part of the health system.

To Health care workers:

Sissolak et al., (2011), identified non-representativeness of health care workers in policy/decision making process within the health system. This research will be a platform to soliciting responses from health care workers and documenting health system barriers that are of prior concern to HCWs. This health risk management research stands to benefit HCWs by promoting safe environment for health service delivery and thereby protecting HCWs and patients.

Potential harm: The researcher will be exposed to TB infection in the course of the research during direct observation and data collection; however, respirators will be worn at all times on study sites. Amidst the workload and busy schedule, health workers being interviewed may be interrupted which may increase the length of patients stay clinics. However, the researcher seeks to minimize such harm by maximizing off peak hours and lunch break of respondents, pre-arranging interview sessions with respondents and ensuring flexibility during busy clinic hours.

4.0 Scope of the study/ Limitations

This study focuses on HCWs as street level bureaucrats who the health system relies on to implement policies through service delivery. Although patients are recognised as co-implementers and an integral part of service delivery, this research is not designed to collect

data from patients. However, observations on the field are likely to generate patient based data. Also, this study employs a flexible design that accommodates changes in methods of data collection or analysis. This minor dissertation is in partial fulfilment of the MPH program in health systems aimed at contributing to the body of research and practice in the field of public health.

The exclusion of non-English speaking participants is a study limitation although the majority of HCWs do speak and understand English. One of the limitations of case study research is generalizability. Study results could be generalizable in similar settings such as primary clinics within Khayelitsha and other South African primary care clinics. However, each clinic may differ in HCW levels of motivation. Therefore, transferability of findings needs to be carefully considered.

Structure of dissertation

This minor dissertation will consist of four parts:
Part A- Protocol
Part B-Structured literature review
Part C- Journal ready article
Part D- Appendices

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PART B: Structured Literature Review

1.0 Introduction

Tuberculosis (TB) and HIV co-infection is one of the public health challenges ravaging low and middle-income countries with the growing threat of totally drug resistant TB (Migliori et al., 2012). Among South Africans, 1% contract TB every year and the country has the highest number of people living with HIV/AIDS globally (Padayatchi et al., 2010; WHO, 2011). According to the WHO (2010), one in four deaths among people in resource-limited settings living with HIV is attributed to TB. Although health-care associated TB affects both Health Care Workers (HCWs) and patients, HCWs are at higher risk of getting infected with drug resistant TB (Menzies et al., 1995; O'Donnell et al., 2010) due to high risk of undiagnosed exposures (Shenoi et al., 2010) and longer hours spent in health care facilities. Effective infection-control practices are critical to preventing transmission and further spread of TB in health-care settings and other congregate settings (Straetemans et al., 2010; Chigbu and Iroegbu, 2010; CDC, 2011). It is recognized that health care settings with high TB/HIV co-infection rates, such as the South African Township of Khayelitsha, are important areas for ensuring TB prevention (Wood et al., 2007; Cox et al., 2010). A key means to prevention is the implementation of TB Infection Control (TBIC). This, however, appears to be difficult to maintain in South Africa (Sissolak et al., 2011; Kanjee et al., 2012). This study investigated barriers to TBIC implementation among HCWs in two Khayelitsha clinics.

2.0 Literature review objective

To inform this research, the objectives of this review were:

1. To assess current recommended TBIC practices globally.
2. To identify factors that prevents HCWs from implementing TBIC, especially in South Africa.
3. To highlight gaps in the literature regarding TBIC practices among HCWs to justify the study objectives.

2.1 Literature Search Strategy

Multiple approaches were used to search for the literature to inform this dissertation. The first search approach was conducted through University of Cape Town (UCT) library catalogue (ALEPH); a number of literature (both electronic and hard copies), books, journals, and government publications were found relevant to the study by entering key words (2.1.2).

An electronic search was conducted through the following databases; EBSCO (Academic Search Premier), PubMed, Science Direct (Elsevier), MedLine, Web of Science and Inter-Science (Wiley) to identify relevant studies in international and local peer–reviewed journals on TBIC.

Most unpublished electronic reports relevant to this study were from the Africa-wide information database. This is due to the relevance of studies to the local context in South Africa. International policy documents were downloaded from websites of World Health Organization (WHO) Stop TB partnership and the USA Centre for Disease Control. Regional and local policy documents were also downloaded from Department of Health websites in addition to government publications borrowed from UCT library.

Another search strategy was joining the GHD-online expert discussion forum on TB infection control as an observer. This was resourceful particularly in identifying recently published literature, unpublished reports and gaining insights to the current discussions around evidence based TBIC practices.

2.1.2 Key words

The following key words (and terms) were used:

- Tuberculosis, tuberculosis in South Africa, health-care associated tuberculosis, nosocomial transmission of Tuberculosis.
- Tuberculosis infection control in South Africa, TB infection control measures, TB infection control practices
- Health system barriers to tuberculosis control, barriers to infection control among health care workers in South Africa, challenges in implementing infection control, health worker motivation challenges and TB infection control challenges among health care workers.

2.2 Quality and relevance criteria by which studies were included

The following criteria were used to determine the quality and relevance of literature to be included:

2.2.1 Relevance: The study needed to be relevant to any of the key words in the study objectives.

2.2.2 Date: Electronic journals need not be earlier than Year 2005 except highly relevant to other recent studies. Books must not be earlier than Year 2000. The specified date was to access current knowledge on TBIC practice.

2.2.3 Study validity/Transparency: Validity of selected studies was assessed based on author's recognition of study limitations and a clear explanation of how bias was minimized.

2.2.4 Language: To minimize selection bias, publications written in languages other than English were included in the review provided the English version was made available.

2.2.5 Exclusion criteria

All studies that did not meet the above study criteria were excluded from the literature review summary.

3.0 Summary of the Literature Review

3.1 Current Tuberculosis Infection Control (TBIC) Practices

TB Infection Control (TBIC) is a 'combination of measures aimed at minimizing the risk of TB transmission within populations' (WHO, 2009; Mehtar, 2010). Infection Prevention and Control (IPC) is a prevention strategy for infectious diseases including TB. TBIC is part of the broader IPC strategy. Provisions for IPC in South Africa are documented in the Health and Safety at Work Act, Occupational Health Act, Public Health Act, Constitutional law and WHO recommendations (McCarthy et al., 2009; Mehtar, 2010; WHO/ILO, 2010). Acknowledging most infection control policies are adapted from developed countries, Mehtar (2008) proposed pre-requisite knowledge building and understanding of TBIC among all HCWs before such policy guidelines could be applicable in South Africa. A draft policy on Infection Prevention and Control was developed in 2007 but is yet to be finalized (Department of Health 2007). Despite this, each primary care facility in Khayelitsha has a TBIC policy (specific to each clinic needs) guiding implementation within clinics. Médecins

Sans Frontières (MSF, Doctors without Borders) developed TBIC policies in form of posters to guide each clinic on how best to implement TBIC within available resources.

Three key public health strategies (3I's) were recommended by the World Health Organisation to reduce the impact of TB particularly among people living with HIV/AIDS (WHO, 2008). These strategies are: Isoniazid Preventive Treatment (IPT), Intensified Case Finding (ICF) for active TB and Infection control (WHO, 2008). TBIC: the third recommended strategy is essentially to protect Health Care Workers (HCWs) and clinic attendees in health facilities from getting TB. With the increase in the number of drug-susceptible and drug-resistant TB cases, infection control (IC) remains a viable prevention tool that needs to be maximized to avert TB-related morbidities and mortalities. Although South Africa has adopted the stop TB 3I's strategy, there remains an inadequate capacity to deliver on many of the urgently needed health-care interventions including TB infection control (Karim et al., 2009).

There is evidence in literature that TBIC may reduce new TB infections (Basu et al., 2007; Shenoi et al., 2010; Bamford and Taaljard, 2010). Although some studies reveal continually reduced incidence of TB during the first five years of highly active anti-retroviral therapy – HAART (Lawn et al., 2005; Currie et al., 2003; William et al., 2003), a systematic review suggests the use of secondary TB prevention strategies such as the three I's (including infection control) alongside treatment to further reduce TB burden (Corbett et al., 2006). Moreso, studies in Thailand and Brazil have shown the effectiveness of TBIC measures in reducing Latent TB even though both studies argue TBIC is not instrumental in reducing TB disease (Yanai et al., 2003; Roth et al., 2005). This argument suggests that TBIC prevents new cases of TB. If TBIC reduces new cases of TB, it can contribute to reducing the prevalence of TB over time.

The burden of TB, especially MDR-TB in study location Khayelitsha, necessitates operational research on how to effectively prevent health-care associated TB. Studies have shown a high prevalence of MDR-TB, XDR-TB in South African district hospitals including Khayelitsha settings (Edginton et al., 2006; Cox et al., 2010). TB case notification rate in Khayelitsha was 1,158 per 100,000 in 2008 (Cox et al., 2010). Similarly, 74% of DR-TB cases diagnosed in Khayelitsha were also HIV-infected in 2008 (MSF, 2009).

TBIC is viewed as a feasible and affordable preventive measure against TB in resource-poor settings (Kaufmann and Walker, 2009). TBIC is furthermore considered a sub-set of broad infection control policies and labour/occupational health policies in South Africa (National Department of Health, 2011). Mathematical modelling suggest the combined practice of administrative, environmental and personal protection measures of TBIC are effective in reducing transmission rates in health care facilities and averting TB related deaths by 50% (Shenoi et al., 2010; Basu et al., 2007; Bamford et al., 2010; Heysell et al., 2011). With the important role TBIC plays in reducing health-care associated TB, implementation becomes a key issue.

Hierarchical Measures for TBIC

TBIC comprises three hierarchical categories of control measures that ought to be implemented simultaneously to reduce the risk of TB infection control in health care facilities. The three categories of TBIC are administrative control, environmental control and personal protection. Figure 1 depicts the three measures of TBIC and the role of HCWs that implements each measure in health care facilities. The chief goal of TBIC is early diagnosis as well as proper management of TB patients which requires health system strengthening (WHO, 2009; Atun et al., 2010) for sustainable implementation.

3.1.1 Administrative control

Administrative control is the first level of TB infection control aimed at reducing the spread of TB within health facilities. This level of TBIC control encompasses the role of co-ordination, supervision and communication in service delivery. This measure of control is described as the first line of defence against TB transmission within health facilities (Bock et al., 2007). The most important administrative infection control measure is to promptly identify people with TB symptoms (triage), place them on treatment and minimize time spent in health facilities. Albuquerque da Costa (2009) stated that isolated administrative control measure could substantially reduce TB transmission among HCWs in resource constrained TB high-risk settings. Appendix 4.1 outlines details of other administrative control measures according to international guidelines (WHO, 2009) while Appendix 4.2 depicts measures already in place in Khayelitsha clinics (HATIP, 2010). As front-line implementers of TBIC, HCWs are responsible for promptly identifying TB suspects (triage), separate suspects from

other patients, promptly attend to patients and minimize time spent in facilities. As part of administrative control measures, surgical (including paper) masks and cough hygiene aim to reduce the concentration of infectious particles in the air (Mehtar, 2010). An experimental study in South Africa found that wearing of surgical masks by patients reduced MDR-TB transmission by more than half (56%) in health care settings (Dharmadhikar et al., 2012). It requires oversight of HCWs to ensure that all patients wear paper masks consistently and appropriately. However, the health system also plays a crucial management role in the timely and adequate supply of respirators and paper masks.

In practice, administrative measures were least prioritized in South African health care facilities. Studies reveal HCWs still observe low adherence to administrative control measures especially early triage (Heysell et al., 2011; Olson et al., 2011). A study that assessed TBIC in resource-limited setting in rural South Africa district hospitals found that despite a high level of information among health care workers, motivation and behavioural skills needs to be improved through life-long training (Kanjee et al., 2012). The study identified several 'deficits' in administrative measures such as: lack of Infection control policy, poor TB screening process, inadequate separation of TB suspects, inconsistent use of cough hygiene. The health system is thus required to provide resources as well as oversight and leadership in implementing TBIC administrative measures. Training and re-training health care workers, establishing an infection control committee and drafting a facility based infection control plan require a level of health system support for sustained implementation.

3.1.2 Environmental control

Environmental control (otherwise known as engineering control) is the second level of TBIC in health facilities (WHO, 2009). This measure requires the establishment of administrative controls first to ensure proper operation and sustainability (Bock et al., 2007). This entails ensuring adequate ventilation in areas where there is likely to be a high TB transmission risk. This can be done through natural or mechanical ventilation or a mix of both. Natural ventilation can be improved by opening windows and doors leading outside, installing wind-driven air extractor turbines (whirlybirds) in indoor waiting areas, corridors and consultation rooms to increase natural ventilation. Environmental controls also include the provision of sputum collection booths outside out-patient waiting rooms and consulting areas but still within the premises of health facilities (WHO, 2009; HATIP, 2010). Installing mechanical

vents are usually expensive and usually not feasible in resource constraints settings. A recent study revealed the efficiency of wind driven turbines; an environmental TB infection control measure. The air change levels per hour often exceeded WHO recommended level of air change per hour (Cox et al., 2012). Although previous studies have described engineering control measure as expensive and unrealistic in low resource settings, Cox's results proved a possibility of managing infection control within available resources through combined efforts of open turbines and natural ventilation. HCWs' play a vital role in ensuring natural ventilation by keeping windows and doors open daily in health care facilities. Although facility specific TBIC policies promote safe occupational practices of HCWs, priority is placed on administrative control measures such as early diagnosis and initiation of proper treatment.

Similar to administrative control, the behaviour of HCWs can influence consistent implementation of environmental control measures. Keeping windows open, retaining the use of rooms for intended purposes, monitoring the correct and consistent use of ventilation equipment are dependent on the behaviour of HCWs. One of the 'deficits' in environmental control measures was identified as inconsistent natural ventilation during winter months in some health care facilities (Kanjee et al., 2012). This suggests that there is higher risk of health-care associated TB transmission during winter months in such facilities which makes environmental TBIC more difficult.

3.1.3 Personal Protective Equipment (PPE)

The third and last level of infection control is directly for the protection of HCWs and this includes the use of N95 respirators by all clinic staff (WHO 2009; HATIP, 2010; Department of Health, 2007). Respirators protect HCWs who interact closely with patients from TB infection in health care facilities. Ideally, N95 respirators should be fit-tested for each HCW (Mehtar, 2010; Malebati, 2010) but this depends on the willingness of the HCW to ensure proper fit. The N95 respirator for which contains filters that prevent wearers from inhaling the TB bacilli (Fenelly, 1998; Mccarthy, Mosedane and Telliet 2009). PPE measures require compliance of HCWs to correctly wear and consistently use respirators. Stock out and non-availability of such resources can limit health care worker's performance and increase the risk of health-care associated TB.

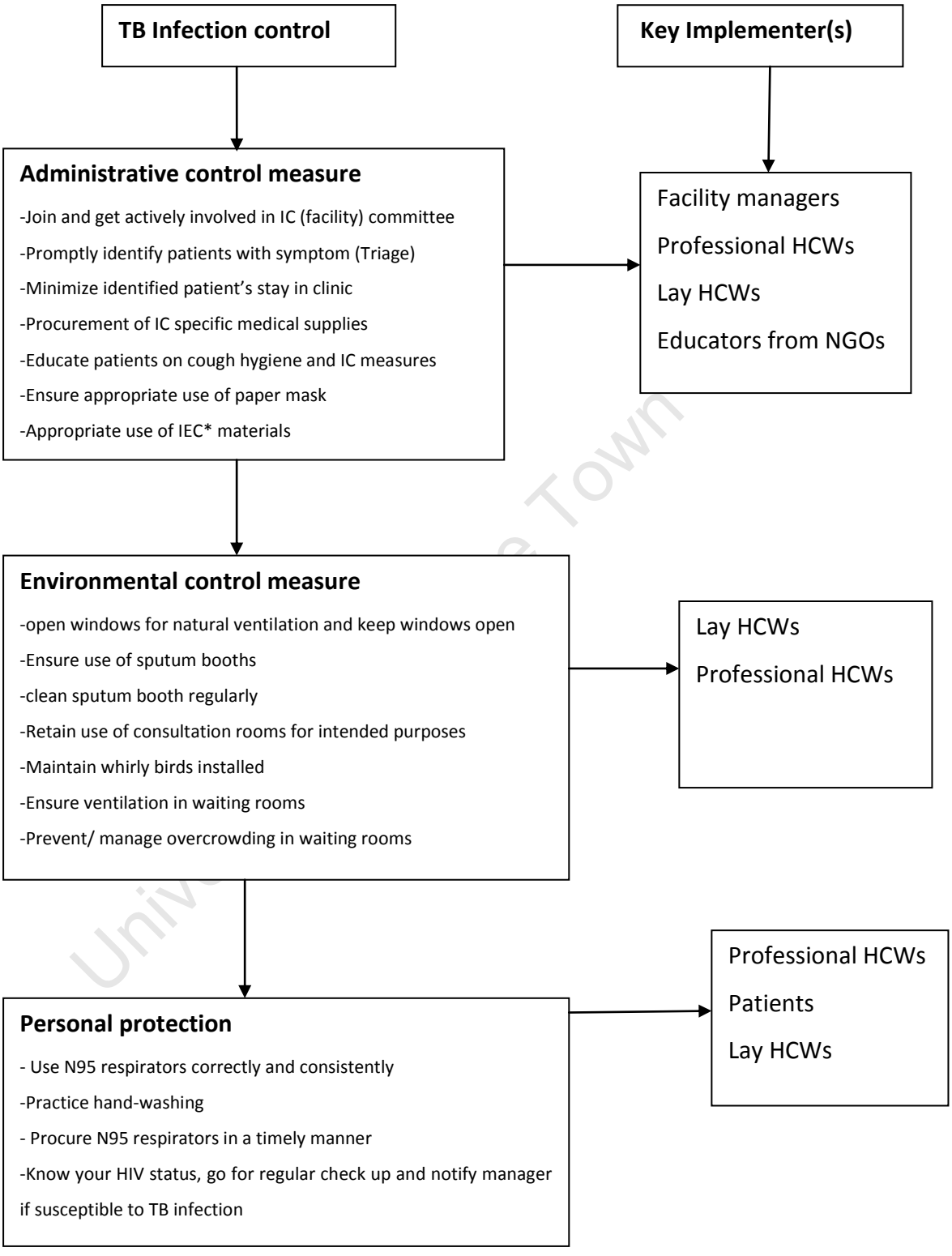

Fig 1: Role of Health care workers in TB Infection Control (WHO, 2009; anecdotal interview with HCWs)

3.2 Barriers to TBIC

3.2.1 Health System Barriers

Overall, the three TBIC measures rely on health system support demonstrated in the provision of adequate administrative and environmental control measures that are available, accessible and acceptable to health care workers (Fenelly, 1998; Nansera, 2010; Kanjee et al., 2011). Evidence from published studies and policies reveal weak health systems as a key barrier to global tuberculosis infection control efforts (Atun et al., 2010; WHO, 2010). Shortage of HCWs: an essential 'building block' of the health system, poor staff motivation coupled with patient overload all contribute to the low morale of HCWs. Health care workers are at risk of being infected with TB in such unsafe work environment. In a pilot study modelling TB care centre for better diagnosis and treatment, Edington (2006) concluded that public health facilities as part of the entire health system poorly support and de-motivate HCWs: major drivers of effective health service delivery. Amidst health system challenges such as staff shortage and work overload, some clinics and HCWs perceive infection control measures as an additional burden while others endeavour to sustain TBIC despite these challenges.

3.2.2 Health Care Workers (HCWs) and Motivation

HCWs are all people engaged in actions whose primary intent is to protect and improve health (WHO, 2007). In the context of this research, health care workers consist of paid and unpaid workers, as well as lay and professional cadres within study sites (i.e., selected health facilities within Khayelitsha). HCWs are sometimes not considered as part of the health system and barriers perceived by providers are often differentiated from health system barriers. This study considers HCWs as actors within the health system and explores barriers to TBIC practices in select primary care clinics.

According to the World Health Report (2010), ineffective recruiting, inappropriate training, poor supervision and inadequate compensation leads to reduced performance resulting in attrition and high turnover of HCWs. There is a link between improving the quality of care to achieve positive health outcomes and HCW motivation. Millennium Development 'Goal 6' aims to combat major pandemics and to set the target for reversing the global incidence of tuberculosis by 2015. However, poorly motivated and inadequately trained health workforce has been identified as a major health system barrier to achieving this goal (WHO 2007).

According to WHO/ILO (2010), a safe healthy work environment can be an incentive for HCW performance and retention. Guidelines for improving access and health care for TB and HIV (WHO, 2010) recognises infection control as an essential component of occupational health aimed at reducing TB exposures among HCWs, their families, communities and population at large. In South Africa like other countries with high burden of TB/HIV, HCWs are at high risk of TB infection and invariably require more training and protection than currently provided (Olson et al., 2011).

In South Africa, a consolidated national report of PHC delivery sites by the department of health acknowledged that 'the morale of personnel plays an important role in service delivery' (Public service commission, 2010). Staff shortage was said to negatively impact on administrative functions of clinic managers. Because of staff shortage, a fixed lunch break was no longer feasible among HCWs who commendably rotate their lunch break period to avoid interrupting service delivery to patients. Unavailability of resources was identified as a barrier to implementation of services among committed HCWs (Public service commission, 2010).

A systematic review assessing the motivation and retention of HCWs in developing countries found that beyond financial and educational incentives, system support such as adequate infrastructure, recognition of HCWs are highly influential motivating factors (Willis-Shattuck et al., 2008). These factors were said to boost the morale of health workers thereby enhancing service delivery performance. Similarly, a study identified resource availability, health worker competence and health worker motivation as determinants of health sector performance (Franco, Bernette and Kanfer, 2002). Although the study found that resource availability and health worker competence are not sufficient to enhance health worker performance, worker motivation in service delivery was described as 'critical' in ensuring health worker performance (Franco, Bernette and Kanfer, 2002).

Sissolak (2011) investigated the factors influencing TBIPC practices among nurses in hospitals and revealed the interconnectedness and overarching pattern of the factors within the health system. Some of the factors impeding TBIC implementation (identified by HCWs) were work overload, inadequate isolation facilities and lack of training. This study aims to

further explore barriers to infection control and understand what role HCW motivation plays in implementing TBIC.

3.2.3 Theoretical framework of HCW motivation

A socio-behavioural approach to assessing how to maintain TBIC practices among HCWs adds valuable insights to epidemiological and clinical investigations (Pittet 2004). Specifically, theory based socio-behavioural models are useful for identifying barriers to TBIC practices among HCWs (Shenoi, 2010; Kanjee, 2011; Woith, 2012). Using the information motivation and behavioral model, Kanjee (2012) associated motivation and behavioural factors (e.g., social support by colleagues, supervision) to ensuring TBIC implementation was maintained among HCWs in South Africa. For this study, the precede-proceed model and work motivation theory were combined to identify factors that may motivate HCWs to implement TBIC (Green and Kreuter, 1999; Franco et al., 2002). Both models were combined to broadly identify organisational factors and intrinsic factors influencing TBIC implementation among HCWs. The precede-proceed model outlines seven phases of health behaviour and factors related to each phase. Implementation and process evaluation (phases 6 and 7) are most applicable because TBIC is an on-going practice that is already being implemented. Therefore, we can refer to this study could be likened to a process evaluation. Franco's (2002) work motivation theory shows the dynamics of HCW motivation to achieve health outcomes such as TBIC. Factors that may influence TBIC implementation among HCWs are predisposing factors (perception of risk and training), reinforcing factors (self-motivation) and enabling factors (work environment) (Green and Kreuter, 1999). Other factors are policy, regulatory and organisational related to TBIC practices. Figure 2 is the conceptual framework informing this dissertation (adapted from Franco et al., 2002; Green and Kreuter, 1999) showing various factors that can influence TBIC practice among HCW within health care facilities.

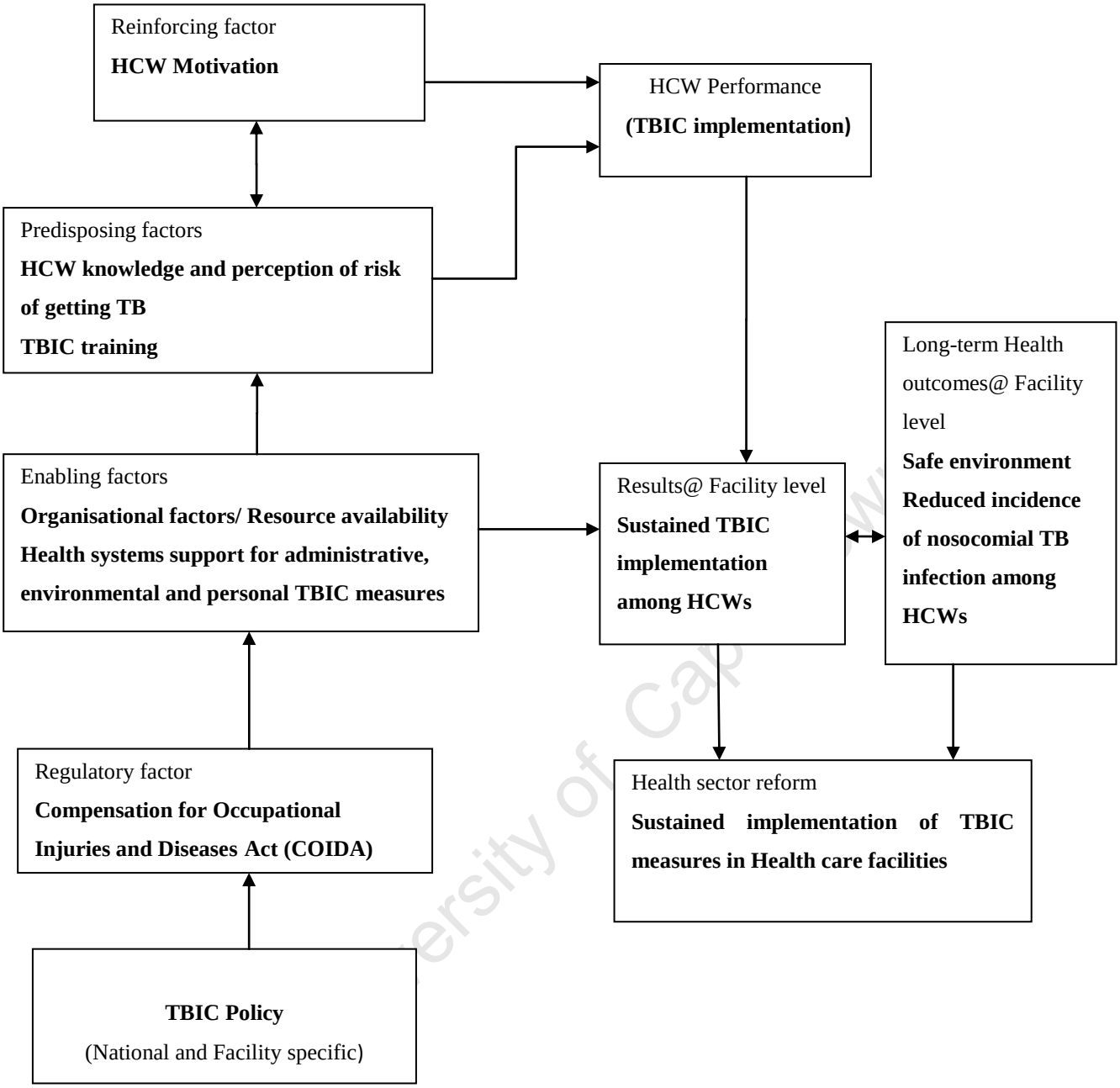

Figure 2: Motivation framework of TBIC implementation among HCWs
Adapted from Work Motivation in the organisational context (Franco et al., 2002) and Precede-Proceed model (Green and Kreuter, 1999)

4.0 Gaps and Contribution of research to existing literature

A number of studies have revealed the need to adopt a multi-disciplinary approach by using behavioural sciences to enhance understanding of TBIC dynamics among HCWs (Hussein 2011, Pittet 2004). Although Hussein (2011) studied maternal mortality related infection control, his findings are broadly applicable to behavioural components of infection control among HCWs and not specifically TBIC. This research will contribute to understanding the behavioural component of TBIC implementation by relating organisational and motivational factors that determine sustained implementation of TBIC among HCWs.

Previous studies that explored TBIC practice among HCWs considered hospital settings (Berhe et al., 2005; Sissolak et al., 2011), high TB prevalence settings (Kanjee 2012) and one of the three measures of TBIC (Cox et al., 2012; Dharmadhikari et al., 2012). Similar to Hussein (2011) other studies focused on the broad spectrum of IC and not specific to TBIC (Yassi et al., 2007; Parmeggiani et al., 2010). One study was useful in national representation of TBIC implementation (Farley et al., 2012) but it was difficult to transfer results to district and sub-district levels. A few studies, though relevant to TBIC, were not conducted in South Africa and may be limited in terms of socio-cultural context (Yanai et al., 2003; Woith et al., 2010). Table 1 presents the summary of 15 selected articles reviewed on barriers to TBIC practice among HCWs and identifies gaps in each literature that requires further research. Although this study does not address all the gaps identified in the selected literature, it aims to identify barriers to TBIC practice in sub-district primary care clinics in South Africa.

Table 1: Identification of gaps or needs for further research from relevant literature

S/N	Author(s)/ Year of publication	Objective	Relevance to study	Findings	Gaps
1.	Kanjee et al., 2012	To further characterize HCW adherence to TBIC implementation using a behavioural model-Information, motivation and Behaviour(IMB)	Explored knowledge, motivational and behavioural skills that determine HCWs adherence to TBIC implementation	Knowledge of TBIC measured does not necessarily translate to TBIC practice. Motivation and behavioural factors were associated with TBIC practice among HCWs.	HCWs in rural hospitals with one of the highest incidence of drug resistant TB may understandably comply with TBIC measures compared to primary health care facilities.
2.	Cox et al., 2012	Assess the efficacy of wind driven air turbines as an environment TBIC control measure	Effectiveness of environmental control measure in selected Khayelitsha primary health care clinics	Ventilation with open turbine and grate exceeded the WHO recommended level for air change in 3 of the 4 rooms studied.	Only environmental control measure was studied in a conditioned experimental setting.
3.	Farley et al. 2012	Operational evaluations of IC in drug resistant TB settings	TBIC practice among HCWs in South Africa	Knowledge about TBIC was relatively highest among HCWs with higher clinical training although such knowledge did not translate to different TBIC practice. Non-standardized TBIC practices across facilities.	Although study reported TBIC practice in drug resistant settings at National level, Findings may not be generalizable to TB/HIV clinics at district level.
4.	Dharmadhikari et al., 2012	To "quantify the efficacy" of surgical masks worn by MDR-TB	Explored the effectiveness of using surgical masks: an	Surgical masks worn by patients can significantly reduce MDR-TB	Although a relevant background to study, it does not explore TBIC practice among

		patients	administrative TBIC measure	transmission by 56%	HCWs
5.	Kanjee et al., 2011	To characterize TBIC implementation of hospital staff in a resource limited TB setting	Specifically explores HCWs knowledge, attitude, practice of TBIC in a similar resource limited setting	Similar to Yassai (2007), this study also found out that HCWs are motivated by organizational support to implement TBIC. This study emphasizes the need to imbibe behavioural science approach in promoting TBIC implementation among HCWs.	Baseline study was conducted just after reported incidence of MDR/XDRTB. Further operational research study explored TBIC practice among HCWs using IMB model (See Kanjee 2012).
6.	Sissolak et al., 2011	Identify risks related to health-care associated TB	Factors influencing TBIPC practice among nurses in Tygerberg Hospital, South Africa	Factors emerged in interconnected overarching health systems theme in relation to health care facility, health care workers (nurses) and patients.	A hospital 'in-patient' setting may not be generalizable to district primary health care settings where they operate out-patient clinics. Study was only conducted among a category of HCWs: nurses.
7.	Parmeggiani et al., 2010	Assess knowledge, attitudes and compliance of HCWs to standard precautions of health-care associated infections (HAIs)	HCWs compliance to Hepatitis C and HIV infection control in emergency hospital departments in Italy	Despite high knowledge and positive attitudes of HCWs, there was low compliance to standard precautions. Nurses had higher knowledge, perceived risk and appropriate control measures than doctors.	Study scope is quite broad; not TB specific infection control measures. Study was in Italy and in hospital settings. Difference in geographical location and in-patient hospital setting limits transferability of

					findings to South African primary care clinic setting.
8.	Woith et al., 2010	Assess knowledge of TBIC practices among HCWs	Knowledge of TBIC practices among HCWs in community based TB care facilities in Russia.	HCWs' knowledge deficit was found mainly in infection control. Overall, doctors were significantly more knowledgeable than nurses. This contradicts Parmeggiani's (2010) findings that showed nurses were more knowledgeable than doctors regarding infection control measures	Knowledge was not merged with TBIC practices among HCWs. Although the study was in settings similar to proposed study (community based health care facilities), the geographical disparity and cultural diversity between Russia and South Africa limits its applicability to study.
9.	Yassi et al., 2007	To assess determinants of HCWs self-reported compliance with IC procedures	Explores IC practice among HCWs in health care facilities	Environmental and organizational factors were strongly correlated as key determinants of HCWs' compliance with IC procedures. HCWs who perceived a strong commitment to safety in their institution were 2.5 times more likely to be compliant than HCWs who did not perceive a safe work environment.	Although very relevant to health systems research, this article did not focus on TB infection control but broadly looked into IC procedures. A follow up qualitative study may be insightful.
10.	Joshi et al., 2006 (Review)	To summarize evidence on TB incidence and prevalence among	Efficacy/Efficiency of TBIC measures in preventing TB	Health-care associated infection is an occupational problem among	Broad spectrum of analysis and findings. Need to conduct a research in local

		HCWs To evaluate impact of TBIC measures carried out before the review	among HCWs	HCWs in low and middle income countries (LMIC) There is a need to implement effective appropriate TBIC measures in health care facilities of LMIC	context of country being studied to understand the nature of barriers to TBIC implementation among HCWs.
11.	Berhe et al., 2005	To assess HCWs' perception regarding adherence to IC practices	Explores adherence to IC practices among HCWs. Study also considered motivational factors	Due to motivational differences, HCWs compliance to IC practices differed by cadres/occupational categories. This suggests a need for TBIC training for various cadres of HCWs.	Hospital based study and did not specifically study TBIC practices among HCWs in community based clinics.
12.	Pittet D., 2004 (Review)	To explore behavioural sciences theories that can be applied to improve IC practice among HCWs	Behavioural science theories applicable to TBIC practice	Among other factors, HCWs' compliance to hand-washing is associated with organisational and system constraints.	Need to disaggregate factors influencing TBIC practice among various cadres of HCWs. Study considered only hand-washing.
13.	Franco et al., 2004	To explore motivation determinants and outcomes among HCWs.	Motivation theory used as conceptual framework for explaining TBIC practice among HCWs	Worker motivation is a complex dynamic process influenced by individual factors, organizational factors and cultural factors. Non-financial incentives can improve health worker motivation	HCW behaviour has not been used to explore and explain TBIC practice among HCWs.
14.	Yanai et al., 2003	To describe the effectiveness of health-care	TBIC effectiveness in reducing health-	HCWs are increasingly exposed to active TB patients	This study shows effectiveness of TBIC in reducing hospital

		associated TB preventive measures.	care associated TB among HCWs	and are at risk of health-care associated TB especially in the first year of employment. TBIC measures are effective in reducing the risk of health-care associated TB.	acquired TB; there is need to explore factors that predict sustained TBIC implementation among HCWs. Moreso, health system is different in Thailand compared to South Africa.
15.	Kretzer and Larson., 1998 (Review)	To better understand how to target more successful IC intervention strategies among health professionals	Predictors of behavioural patterns among HCWs in relation to IC practice in health care settings	Results reveal it is important to take account of both individual and organizational factors in seeking ways to improve IC practices among HCWs	Need to consider organizational (health systems) factors influencing TBIC practice among HCWs.

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Part C: Journal ready manuscript

Barriers to Implementation of Tuberculosis Infection Control amongst South African Health Care Workers[1]

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Abstract[2]

Background

Tuberculosis (TB) is an airborne infectious disease that can be transmitted from one person to another. Health Care Workers (HCWs) in South Africa are at risk of acquiring TB infection from their work environments. Although Tuberculosis Infection Control (TBIC) measures put in place in clinics may reduce infection transmission, implementation remains a major challenge.

Objective

This study assessed barriers to implementation of TBIC among HCWs in two South African primary care clinics in a Cape Town township with a high TB prevalence.

Methods

Using a case study approach, among various cadres of HCWs, data was collected by direct observation, key informant interviews, semi-structured interviews, focus group discussions and document review. The data was analysed using thematic analysis and interpretive analysis.

Results

Identified barriers and enablers to TBIC implementation were linked with health systems and HCW motivation. Some of the barriers were inadequate HCW training on TBIC, a non-responsive compensation policy and the perception that a busy clinic schedule leaves no time for TBIC implementation. Resource availability, adequate human resources and leadership enabled HCWs to implement TBIC. Measures such as use of respirators and masks tend to be prioritized by HCWs ahead of administrative and environmental measures that are potentially more effective in reducing TB infection.

Conclusion

HCW motivation plays a crucial role in consistent implementation of TBIC measures. In-service training and leadership characterized by delegation with supervision could motivate HCWs.

KEYWORDS: Tuberculosis infection control, health care workers, implementation barriers, motivation, clinics, South Africa.

[1] *In line with Plos One Journal guidelines (Appendix 6)*

[2] *Adapted from dissertation abstract*

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Introduction

Health care workers (HCWs) and patients are at risk of acquiring tuberculosis (TB) infection in health care facilities [1]. Such risk characterises TB as a dual public health threat - first as a communicable disease and secondly as an occupational health hazard. Overall TB prevalence among HCWs in South Africa was 5% in 2009 while HIV prevalence was approximately 16% in 2002 [2, 3]. HIV co-infection and TB drug resistance (DR-TB) worsen the overall problem of TB in South Africa [4]. Both the burden of TB disease driven by high HIV prevalence and increased vulnerability to TB disease increase the likelihood and significance of health-care associated TB transmission [5,6,7]. Health-care associated infections refer to infections that are acquired by staff or users of health services within health care facilities [8]. The risk of health-care associated TB has been recognised in health care settings worldwide [9,10]. In South Africa, health-care associated infection is particularly an issue in communities with high drug-resistant TB and HIV prevalence [11,12,13] such as Khayelitsha.

Khayelitsha is a poor urban township located 40 kilometres from Cape Town, South Africa, and has an estimated population of 500,000[14]. Within the South African health system, the district or sub-district level, such as Khayelitsha, is the primary level of care and first point of call for health service utilization. There are 10 primary care clinics in Khayelitsha and each of these clinics has been sensitized on TBIC and has commenced implementation [15].

Khayelitsha, the largest township in South Africa's Western Cape Province, has one of the highest TB and HIV co-infection rates in South Africa and globally with TB case notification of 1,158 per 100,000 per year [16]. About 70% of all TB patients were also HIV-infected [17]. One of the strategies aimed at reducing the TB burden in Khayelitsha is to prioritize TB Infection Control (TBIC) in health facilities to limit nosocomial transmission. Although measures of TBIC have been implemented in all Khayelitsha clinics, such measures are difficult for HCWs to maintain [15, 18]. This study explores barriers to TBIC implementation among HCWs in two primary care clinics in Khayelitsha.

Tuberculosis Infection Control (TBIC) Practices

TBIC is part of a broad range of Infection Prevention and Control (IPC) measures recommended by the World Health Organization (WHO) and adopted locally in South Africa [8,19,20]. Provisions for IPC in South Africa are documented in the Occupational Safety and Health Act, Compensation for Occupational Injuries and Diseases Act, Public Health Act and the country's Constitution [21,22]. The WHO recommends TBIC as one of the three strategies for reducing the burden of TB in HIV prevalent settings - these are: Isoniazid preventive treatment, intensified case finding and infection control [23].

TBIC is a combination of measures used as part of a holistic approach to effectively reduce the risk of TB transmission within crowded settings, including health care facilities [19,20]. TBIC is comprised of three categories of measures that are hierarchical but usually implemented simultaneously to reduce the risk of health-care associated [19]. These measures are administrative controls, environmental controls and the use of personal protective equipment. Administrative controls are the most prioritized of the three, described as the 'first line of defence' against TB transmission in health care facilities because of their potential for removing infectious risk through prompt diagnosis and treatment [6, 24]. They include promptly identifying clients with TB symptoms, placing them on treatment and minimizing time spent in a health facility. Other components of administrative controls include, staff training, establishing infection control committees, cough etiquette, health education and the use of paper masks by patients [20]. Environmental control helps to reduce the number of infectious droplets in the air through controlling the direction of airflow and natural ventilation (i.e., keeping windows open) or mechanical ventilation (i.e., installation of vents and wind-driven air extractor turbines) [20]. The third measure of TBIC is the correct and consistent use of personal protective equipment (PPE, e.g., N95 respirators) which contains filters that prevent wearers from inhaling the TB bacilli [25]. Implementing PPE for TBIC is ranked third because they it is regarded as a last resort that complements administrative and environmental control measures. Whereas other measures prevent more than one person from getting infected with TB, PPE protects only the wearer. Although there is little direct evidence, theory and mathematical modelling suggest that the consistent implementation of the trio of TBIC measures can significantly reduce TB transmission within health care facilities [7,10,13]. HCWs are seen as the front-line implementers of TBIC in

health care facilities and therefore play a vital role in the effective and consistent implementation process.

Role of HCWs' Motivation in TBIC Practice

Since HCWs are an essential part of the health system [26] that implements health policies within health care facilities, understanding what motivates HCWs to implement TBIC is crucial for identifying barriers to implementation. TBIC requires consistent implementation by HCWs to reduce TB transmission in clinics. A poorly motivated and inadequately trained health care workforce has been a major health system barrier to achieving the Millennium Development Goal of reversing the global incidence of tuberculosis by 2015 [4,26]. In South Africa, barriers to TBIC implementation reported by HCWs are TB/HIV related stigma and resource constraints [27, 28]. Resource availability and worker competence are not sufficient to enhance health worker performance; rather, worker motivation in service delivery is critical in ensuring sustained health worker performance [29]. Exploring barriers to TBIC implementation, this study further assessed the willingness of HCWs to maintain TBIC practices in health facilities by identifying factors that motivate and demotivate HCWs.

Methods

A case study design [30, 31] was used for assessing how HCWs implement TBIC in two clinics within Khayelitsha from March to May 2012. It would be difficult studying barriers without relating it to the clinic environment where HCWs implement TBIC. Case study design was used to explore challenges HCWs experience while implementing TBIC within clinics so as to relate study context (clinics) to the practice being explored (TBIC). In line with the case study design, a conceptual framework (Figure 1) on HCW motivation within the work environment was further used to explore barriers to TBIC practice.

Study Population

The study population included eight lay and eleven professional HCWs (N = 19) from two Khayelitsha clinics. The study participants constitute 28% of all HCWs (N= 69) working in both clinics. Professional HCWs included: nurses, doctors and pharmacists working in the study clinics. Lay HCWs included clerks, nursing assistants, general workers, and educators from NGOs. Most professional and lay HCWs in both clinics were employed by the City of Cape Town municipality. However, one lay HCW was employed by NGOs.

Data collection and Sampling

Two Khayelitsha clinics were purposively selected, using the following inclusion criteria: a clinic with at least 15 HCWs and a patient load of at least 30 per day and due permission given by facility manager. Based on the inclusion criteria, staff of *Médecins sans Frontières* (MSF, Doctors without Borders) familiar with TBIC in Khayelitsha nominated five clinics eligible for the study. Site visits were conducted to these five clinics and only three out of the five met the inclusion criteria. Two clinics were finally selected, based on inclusion criteria and accessibility. Convenience sampling was used to recruit HCWs to compensate for the busy schedules and heavy workload in each clinic. All interviews and focus group discussions were conducted in English at the clinics by the principal researcher (first author).

Data was collected by direct observation of HCWs implementing TBIC within clinics (5 working days per clinic), key informant interviews among facility managers and a sub-district health representative (n=3), semi-structured interviews among professional HCWs (n=7) and Focus Group Discussion (FGD) among lay health care workers (n=3). An observational grid and interview guidelines were developed as data collection instruments.

Description of Clinic A and Clinic B

Health service delivery in Clinic A is threefold: child health, women's health and adult chronic care. Its package of care includes adult curative, child care, reproductive health, basic ante-natal care, diagnosis and treatment of sexually transmitted infections (STIs), TB as well as Antiretroviral (ARVs). Out of a total of 39 HCWs in Clinic A, 11 health care workers participated in the study. One key informant interview, three semi-structured interviews and two focus groups were held. Only lay HCWs were initially scheduled to participate in FGDs according to the study protocol but due to work overload in the clinic, both professional and lay HCWs (working in TB section) had to participate in an additional FGD.

Clinic B provides a two-fold health service delivery: Child health and women's health. With the exception of adult chronic care, clinic B offers services similar to clinic A. From a total of 30 HCWs in Clinic B, eight HCWs participated in the study. One key informant interview, four semi-structured interviews and one FGD were held in Clinic B. Three lay HCWs participated in the focus group discussion.

Ethics

The study, in line with the Helsinki declaration, was approved by UCT Human Research Ethics Committee and the City of Cape Town Health committee (Appendix 5.1 and 5.2). Facility managers of both clinics were asked to participate in the study and handed a one-page research summary a week before the study commenced. All participants gave written informed consent before participating.

Data Capturing

The principal researcher (first author) transcribed audio clips from interviews. A colleague (Masters in Public Health student) validated transcribed notes with audio clips so as to minimize reporting bias. Participants' responses were clarified after interviews and during report writing (member checking) to ensure reliability of data. Member checking is a process whereby a researcher seeks to minimize reporting bias by summarizing written notes and asking participants if their responses were well represented in words.

Data Analyses

Data was analysed using thematic analysis and interpretive analysis [30, 31]. Prior TBIC assessment reports [14] of both clinics were compared with data from case study research during analysis.

A codebook was manually developed with themes generated from the interview guidelines and the themes which emerged from HCWs' responses. Filter questions were incorporated into interview guidelines to ensure data reliability. For example, "what enables you to implement TBIC?" is a filter question to "what motivates you to implement TBIC?"

Based on a motivation framework developed from the literature on TBIC implementation (Figure 1), factors that motivate HCWs to implement TBIC were identified from precede-proceed model and work motivation theory[29, 32]Although we sought to explore barriers to TBIC practice, we also identified potential enablers from HCW responses and direct observation.

Results and Discussion

Demographic Characteristics of participants

More female (n=14) than male (n=5) HCWs participated in the study. The number of professional female HCWs (n=7) and lay female HCWs (n=7) who participated in the study was the same. Only one male lay HCW participated in the study, the other four were professional HCWs. Of all participants, 11 were professional HCWs while 8 were lay HCWs. Respondents' levels of education varied from Grade 10 to a Masters degree, with most having professional nursing degrees. The highest level of education for lay HCWs was secondary schooling (Grade 12) while professional HCWs had tertiary education. The number of years worked in health care facilities ranged from two weeks to thirteen years, with an average of one year across respondents. Lay HCWs had worked in the clinics longer than most professional HCWs. Of the nineteen HCWs interviewed in both clinics, nine worked solely in the TB section of the clinic. The age of respondents varied between 27 and 60 years. Lay HCWs were much older (34-60 years) than professional HCWs (27-55 years) in both clinics.

Enablers of TBIC implementation among HCWs

Fear of contracting TB was the most commonly reported factor that motivates both lay and professional HCWs to implement TBIC measures. Interviews reveal that drug resistant TB instils the greatest fear in professional HCWs to implement TBIC due to the long treatment regimen and low treatment success rates compared to drug susceptible tuberculosis.

> *Yes, MDR-TB, that's why you have seen me trying to wear masks these days… I think that is like really scaring us now, because you know what, I don't know when a client comes in if he has MDR or not.*
>
> *P1-Professional HCW*

The above quote suggests that some professional HCWs understand the principle that any client visiting the clinic could have TB and as such all clients should be treated as possible TB carriers. This also shows that some professional HCWs are aware and concerned of the risk of getting TB prior to patient diagnosis. Professional HCWs are more knowledgeable than lay HCWs perhaps due to professional training on drug-resistant TB and closer contact

with clients. Although lay HCWs also expressed fear of getting infected as a key factor that motivated them to implement TBIC, they did not refer to DR-TB specifically.

I am scared of getting TB. P2- Lay HCW

Based on the motivational theory (Figure 1), fear is a predisposing factor to implementing TBIC among both lay and professional HCWs in both clinics. Professional HCWs who work in the TB section mentioned improved health outcomes such as patients' weight gain as motivating factors for service delivery generally beyond TBIC practice.

> *I must say we are taking the risk because when you see a client come in here unable to walk and next week he's walking, a couple of months they gain weight…it is quite rewarding in that sense.*
>
> *-P3 Professional HCW*

Resource availability

Professional and lay HCWs are more likely to implement TBIC when resources are provided in the form of infrastructure, human resource and consumables (e.g., N95 and paper mask). Professional HCWs mentioned the crucial role of human resource availability in TBIC practice, especially with regards to reduced workload per staff member, leaving more time to implement TBIC.

> *Last year, we asked for more staff, we are happy because they have recruited more people, now we can listen to TBIC, we have more people and more time to implement.*
>
> *P3-Professional HCW*

In terms of resources provided by the health system (potentially enabling factors), both professional and lay HCWs in both clinics described respirators and paper masks as 'generally available'. However, two professional HCWs stated that they do experience shortages of stock and may be forced to re-use respirators at such times. Key informant interviews revealed that proper supply of stock was linked to transport and logistics issues relating to the regular supply of consumables. Implementation of TBIC among HCWs was also determined by enabling factors. Health system support characterised by leadership,

resource availability, operational policies enabled HCWs to implement TBIC. This finding is in line with previous research that organisational support and commitment to health workers' safety strongly motivates HCWs to implement TBIC [27,33].

Leadership by delegation-Infection Control Committee

As a further administrative control measure, a facility manager assigned responsibility for IC to a professional HCW as the 'Head of the Infection control committee'. Such delegation, combined with on-going supervision, seemed to have underlined TBIC as a priority in Clinic B compared to Clinic A where infection control committee is yet to be functional.

> *There is someone I have given the portfolio to who is championing IC. He is the one doing IC audit on a monthly basis and then we discuss it with the general assistants.*
>
> *P4-Professional HCW*

Supervision

It was observed that HCWs in clinic B used respirators more consistently compared to clinic A. Key informant interview revealed that in Clinic B, the facility manager who had earlier observed the inconsistent use of respirators among HCWs organised a fit-test of 'N95 respirators' to encourage sustained use of respirators among staff. The fit test enabled HCWs to use respirators as indicated by this respondent:

> *Last year, we had fit testing sessions. I asked the TB/HIV coordinator to come and do a fit test for all the staff- those working in the TB room. So it fits them properly.*
>
> *P5-Professional HCW*

Although HCWs' discomfort while using respirators can be subjective according to individual needs and preferences which the health system may not be able to address, fit tests can minimize discomfort by helping HCWs to identify most suitable respirators.

After the fit-tests, one of the HCWs working in the TB unit was seen not wearing a respirator. The manager then requested a signed document stating the HCW was not willing to use the PPE provided by the district health system. This punitive approach seems to work because the same HCW began wearing a respirator during later observations. HCWs need to be supervised and constantly reminded about maintaining TBIC practices in clinics. Typically,

one would say the facility manager ought to take responsibility for supervision but if each clinic has an IC officer dedicated to ensuring daily TBIC implementation is likely to be more effective. However, the setback in hiring an IC officer is the over-reliance of HCWs on the individual; whereas, TBIC is a collective responsibility of professional and lay HCWs and not just one individual. The experience of the head of IC committee in one of the clinics also suggest the tendency of HCWs to avoid taking responsibility for IC once a person is assigned to champion the implementation process in clinics. Rather than hiring an IC officer, facility managers may re-activate the clinic IC committee by assigning HCWs across all sections of the clinic. However, HCWs tend to be influenced by the social norm when colleagues wear PPE. One HCW declared:

> *…[in] this particular clinic, I see that everybody wears a mask more than in other clinics which is encouraging….I think when you are working with people who are conscious of IC, it makes you more conscious of IC.*
>
> *P6-Professional HCW*

Similar to our findings, a recent South African study associated staff motivation such as support from colleagues with implementation of TBIC among HCWs [34]. In-service training could be a potential platform to garner support for implementing TBIC in clinics.

HCW screening for TB

On HCW screening for TB, the health system makes diagnostic services readily available to staff. TB screening is voluntary and usually initiated by HCWs. When asked if TB screening is available to HCWs, one of the interviewees responded:

We are allowed to whenever you feel like. If I feel like I want to cough or have an x-ray because maybe I am suspecting, that is in place.

P3-Professional HCW

Such provision of TB screening services to HCWs is an enabling factor (Figure 1) for TBIC practice. If HCWs are provided with needed services that enhance their health such as screening for TB, they are more likely to feel supported by the health system and implement TBIC. If screening services were unavailable, HCWs are likely to feel de-motivated.

Barriers to TBIC implementation among HCWs

Uncomfortable respirators

Despite the fear and high risk attributed to TB, HCWs admitted they are de-motivated to comply with PPE requirements by the discomfort and suffocating nature of respirators provided. They mentioned a difficulty in breathing aggravated by personal health challenges, pregnancy or other conditions.

> *The challenge and de-motivator is difficulty in breathing using N95*
>
> *P7- Professional HCW*

Non-proactive use of respirators

An important finding is the non-proactive way HCWs use respirators by only wearing them after they know the TB status of a patient.

> *I only wear mask when I know a patient has been diagnosed. It is suffocating, a communication barrier and feels hot.*
>
> *P8-Professional HCW*

Such non-proactive use of respirators reflects a lack of understanding as to who is more likely to be infectious. Undiagnosed and untreated TB cases that will be infectious are mostly found in the waiting areas of clinics [7]. Wearing respirators only for known TB cases is therefore a barrier to consistent TBIC implementation among HCWs.

HCW perception of TB concentration in certain clinic sections

Lay HCWs not working in the area of TB did not see a need to use PPE because they did not perceive they are at high risk of acquiring TB. In Clinic A, lay HCWs (assisting the TB team) did not use respirators while attending to patients because of their perceived low risk of contracting TB. Further probing on the possible reasons for the perceived low risk revealed that HCWs associate consistent use of respirators with HCWs working in TB sections or working with diagnosed TB patients. As far as they are concerned, TB is concentrated in one section of the clinic; that is the TB section.

Therefore, the perception is that spending a few minutes in the TB room does not predispose them to TB infection as stated by these respondents:

> *I don't work in TB room full time, just helping out so I don't need to wear masks.*
>
> *P9-Lay HCW*

> *When I was working in TB room, I used to wear respirators but it chokes me. I feel very uncomfortable, but now I no longer work there so I don't have to use it.*
>
> *P10 -Professional HCW*

This perception that an airborne infection such as TB is only restricted to the TB section of the clinic is a barrier to TBIC implementation among HCWs that needs to be addressed during staff meeting and by displaying IEC posters in all sections of the clinic. For example a poster that reads 'TB somewhere in the clinic is TB everywhere in the clinic: are you protecting yourself?' can be posted in each section of the clinic to inform HCWs and clients.

Non-responsive Compensation policy

Another de-motivating factor expressed by HCWs was the non-responsive compensation policy, should they ever get active TB disease. Compensation for active TB disease is a regulatory factor (Figure 1) that can motivate HCWs to sustain TBIC practices by being financially responsible for their TB disease. Although TB is a compensatable disease according to the Compensation for Occupational Injuries and Diseases Act (COIDA), one HCW commented:

> *The thing is with TB and being a health worker, should I get it, I know it's gonna be my problem. I won't be able to prove that I got it here. There is nothing in place that says if you are working in TB dept, you will be compensated. So I guess if you work here, it is at your own risk, that's how I feel.*
>
> *P3 -Professional HCW*

A finding from a key informant interview revealed that HCWs are not required to prove the infection was health-care associated. Further probing on the nature of compensation HCWs expect from the health system revealed both financial and non-financial.

It could come in many different ways, remuneration is always a good thing, give me more money, sometimes recognition, even if it's not in form of money.

P3-Professional HCW

Compensation (COIDA) policy serves as a regulatory document that supports reimbursement of HCWs who develop TB disease. Because of bureaucratic process and delays, HCWs see TB as a 'personal problem' and not an institutional problem. Previous research suggests that such lack of trust in the system can be a barrier to motivation [44] of HCWs who implement TBIC.

Patients' non-compliant attitudes

One other de-motivating factor mentioned by lay HCWs in both clinics was the disrespectful and non-compliant attitudes of patients. This finding is in line with a previous study that recognised the contributing role of patients to effective TBIC practice [28]. Patients sometimes rebel against use of masks by wearing them inappropriately or not wearing mask at all, as outlined by this respondent:

They are so rude…sometimes you talk to them nicely "sisi, others are wearing masks, please you must", but they say they can't because they have rights. I usually tell them yes, you have rights but before you use your rights, you must know others have rights and never bad-luck other people's rights."

P11 -Lay HCW

Patients' resistance to comply with lay HCWs attempt to implement TBIC measures and their assertion of rights may be related to the Patient Rights Charter in South Africa, one of the post-apartheid strategies to address inequality [35]. Similar to our findings, Raphaely [36] stated that patients might exercise their rights in a manner that is unacceptable to health care providers. This resistance may be a barrier to successful TBIC implementation which needs to be further investigated and duly addressed. However, the Patient Rights Charter acknowledges the responsibility of the patient to respect the rights of other patients and health care providers as well as protect the environment.

No time for TBIC

Both professional and lay HCWs perceive TBIC as a separate agenda from their routine tasks that they are being mobilized to support. Some professional HCWs relate TBIC implementation to HCW being paranoid particularly in such a busy environment which they already find challenging. Although HCWs perceive they are at risk of getting TB and particularly dread being infected with DR-TB, they feel too busy to adhere fully to TBIC measures. It appears as though professional and lay HCWs are initially motivated by fear to implement TBIC but become so familiar with the working environment that the perceived risk of acquiring TB wanes over time. This perception suggests that TBIC is yet to be prioritized and integrated into service delivery procedures in clinics as illustrated by this respondent:

> *I used to be scared when I started but I have gone past that now…like yesterday we were so busy here, no time to get paranoid.*
>
> *P12-Professional HCW*

Training deficit

According to facility specific policies on TBIC, in-service training is an administrative control measure. Most professional HCWs had not received further training on TBIC. However, two professional HCWs had attended one-day training on TBIC organised by NGOs. Although prior needs assessment report in both clinics have identified refresher training as integral to improved infection control, in-service training is yet to be implemented in these clinics. Two predisposing factors (Figure 1) that determine sustained TBIC practice are HCWs' perception of risk and the training they have received on TBIC. If HCWs perceive they are at risk, they are more likely to participate in training and implement TBIC in a consistent manner. Research suggests that improvements recorded in the 'work and systematic training' of health workers at primary health care level contributed to successful TB control [37]. Studies have also shown the benefit of in-service training to improved TB care in resource constrained settings within South Africa [38]. Sustained TBIC implementation requires training focused on behaviour change communication, rather than knowledge acquisition [27]. In-service training can easily bridge the gap between knowledge and practice identified as a barrier to TBIC practice in previous studies [34,38,39,].

In line with Berhe's findings [40], in-service training could be more effective if designed to meet various needs of lay and professional HCWs.

Inadequate ventilation

Inadequate ventilation was perceived by HCWs as a barrier to effective TBIC in clinics. Most professional HCWs in both clinics complained about inadequate ventilation in consulting rooms and TB treatment rooms. While some HCWs generally request that vents be installed in consulting rooms and TB rooms, some HCWs who have attended dissemination meetings on infection control are specifically requesting for the installation of wind-driven roof turbines, 'whirly birds' which may contribute to improved ventilation in rooms[41].

> *I don't see anything like an air vent here…that's bad. I think it will be great if they can improve ventilation. Can they put whirly birds? After that study, I think it made an impact.*
>
> *P13-Professional HCW*

One of the study clinics is an older style building and does not conform to current policy recommendations [19] resulting in poor ventilation in some waiting areas. In this situation, while opening windows may assist with ventilation, issues of clinic design are perhaps more relevant. The health system needs to improve on physical infrastructure that supports natural ventilation in all sections of the clinic, otherwise HCWs will continue to experience challenges in implementing environmental controls.

Lack of shared responsibility among HCWs

Although all interviewed HCWs in one of the clinics knew there was an IC committee, they seemed to be detached and unaware of the actual committee activities. The head of the IC committee works in another section of the clinic, rather than in the TB section itself. This suggests an understanding of the need for TBIC across the clinic, rather than merely in the TB section. When interviewed, the head of the IC committee stated a barrier to TBIC as over-reliance and lack of shared responsibility among other HCWs by stating:

> *The barrier is that they tend to rely on one person….it should be done by everybody. It should start with me and extend to everybody. It should be everybody's responsibility.* *P14-Professional HCW*

There is need to re-sensitize HCWs about their contributing role to effective TBIC practices in clinics. The leadership of IC committees could be rotated across various departments to encourage HCWs to develop a sense of responsibility towards infection control.

Administrative controls

Most HCWs (lay and professional) acknowledged one role they have to play in administrative control measures is promptly attending to clients and educating patients on the use of paper masks. The use of paper masks by patients is considered an administrative control measure and not personal protective equipment because it is effective in preventing the TB aerosols from being spread. Unlike the N95 respirator, paper masks do not have filters that protect wearers from inhaling TB bacilli. Few HCWs mentioned cough etiquette or mentioned displaying Information, Education and Communication (IEC) materials as part of administrative control procedures. However, it was confirmed by direct observation that IEC materials were displayed in clinics. Key informant interviews revealed that facility managers in both clinics perceived their role in TBIC implementation as mainly administrative – that is, to procure TBIC supplies (e.g., respirators, paper masks) as well as ensure HCWs implement TBIC measures in line with facility specific Infection control policy. Facility managers are well aware of their role in supervising and supporting HCWs to implement TBIC per policy.

Prompt attendance to Patients and Use of Paper mask

In both clinics, lay HCWs from other sections of the clinic assisted HCWs in the TB section to dispense TB medications and reduce patient waiting time. Professional HCWs attended to diagnosed MDR/XDRTB patients more promptly than other patients. In clinic A, lay HCWs assisted professional HCWs in attending promptly to patients receiving treatment (DOTS and injection) mostly within 5-10 minutes after arrival. However, in Clinic B, prompt attendance to patients dwindled when HCWs were on tea break resulting in patients removing paper masks or wearing them incorrectly.

In line with clinic policies, patients are requested to pick up paper masks at the clinic entrance and wear them while seated at the waiting area. Table 1 shows that patients generally complied with the wearing of masks in Clinic A. But in Clinic B, data from direct observation show that some patients did not use paper masks consistently. There is a direct correlation between prompt attendance to patients and consistent use of masks.

Such delay may be a reason why patients in clinic A used masks more consistently than clinic B. This suggests that patients also have some role to play in maintaining administrative control.

Policy

There are two key policies for TBIC implementation in the study clinics: a TBIC facility specific policy (designed under an MSF project) and an open window policy (supports environmental control). Findings related to 'open window policy' will be discussed under environmental control measures. Facility specific TBIC policies were publicly displayed on the walls of the waiting room and the facility manager's office in both clinics in the form of a poster. Some professional HCWs indicated they were aware of facility specific TBIC policy guiding implementation but stated that it only emphasized personal protective equipment for TBIC.

There is a TBIC policy that emphasises wearing of respirators by HCWs. If our superior officer visits, we run to get our masks, we know what the policy states.

P15-Professional HCW

The Facility specific TBIC policy does not emphasize the use of respirators ahead of administrative and environmental controls. Perhaps HCWs emphasize these because respirators and masks are tangible and visible, thus creating more of an impression that HCWs can easily relate to in TBIC. Such emphasis on use of respirators could be a reflection of inadequate training of HCWs on TBIC: an indication of a weak health system support.

South Africa is one of several countries that are yet to finalise a National TBIC plan [42]. A draft National policy has been developed since 2007 [43]. HCWs employed by NGOs independent of the City of Cape Town seem to have internalised infection control policy as a reinforcing factor (Figure 1) that helps them maintain TBIC practices as voiced by this respondent:

No one is supervising. But because I was employed by an NGO, in our contract, they wrote that if they catch you not wearing 'masks', you will be sanctioned, so it is my responsibility.

P16-Lay HCW

There is still a gap in policy implementation among HCWs. Policy as an intent is different from policy in practice. Although facility specific TBIC policies have been developed, HCWs still need to understand the hierarchy of implementation and take responsibility for consistent implementation similar to the NGO employee. Sub-district health systems can learn from NGOs' training strategies that contribute to sustained policy implementation among HCWs. The national TBIC plan needs to be finalised as a standard of TBIC practice. A national policy on TBIC would underline infection control as a national priority. If well implemented, such a policy can prevent TB transmission in clinics and other settings.

Environmental controls

According to facility specific TBIC policy, environmental controls recommended to professional and lay HCWs in both clinics are to maximize natural ventilation and avoid being downwind from a TB patient. Professional and lay HCWs in both clinics stated the importance of opening windows daily to ensure there is adequate ventilation in the clinic. Lay HCWs seem to emphasize their key role in environmental control measures as opening windows and ensuring ventilation, even during winter and general cleaning of the entire clinic. An open window policy was circulated in August 2010 to all health care facilities to reduce TB transmission. In both clinics, stickers were placed on all windows reading 'STOP TB-Open the Windows'. However, direct observation shows an inconsistent implementation of the 'open window policy' in Clinic A. One of the waiting areas in clinic B gets over-crowded daily, yet it is less ventilated compared to the other two waiting areas This low level of ventilation is due to clinic design as there was no window in that area.

Personal protective equipment (PPE)

Ideally, the use of a respirator, such as a PPE, is secondary to administrative and environmental control measures. During interviews and discussions, HCWs did not differentiate between paper masks (for patients) and N95 respirators (for HCWs) but generally refer to both as 'masks'. Only one professional HCW referred to personal protective equipment appropriately as a 'respirator':

> *My role is to take responsibility to ensure decreased transmissibility, to counsel patients in IC…I wear an N95 respirator most of the time*
>
> *P17-Professional HCW*

Respirators and masks do not serve the same purpose in TBIC. While respirators have filters that protect the wearer, paper masks prevent the spread of aerosols that is transmissible. Training HCWs to distinguish between these two is requisite to appropriate use of masks and respirators.

Both lay and professional HCWs need to understand that PPE is not a primary TBIC measure and the implications of making it the primary measure. TBIC implementation will not be effective if HCWs associate use of respirators and masks to TBIC, since this is only supplementary to the key administrative and environmental controls. Refresher training on TBIC will go a long way towards debunking such misconceptions on the hierarchy of TBIC implementation among HCWs. Infection control committee needs to be functional in each clinic. The clinic IC committee is a platform where local barriers to TBIC can be addressed.

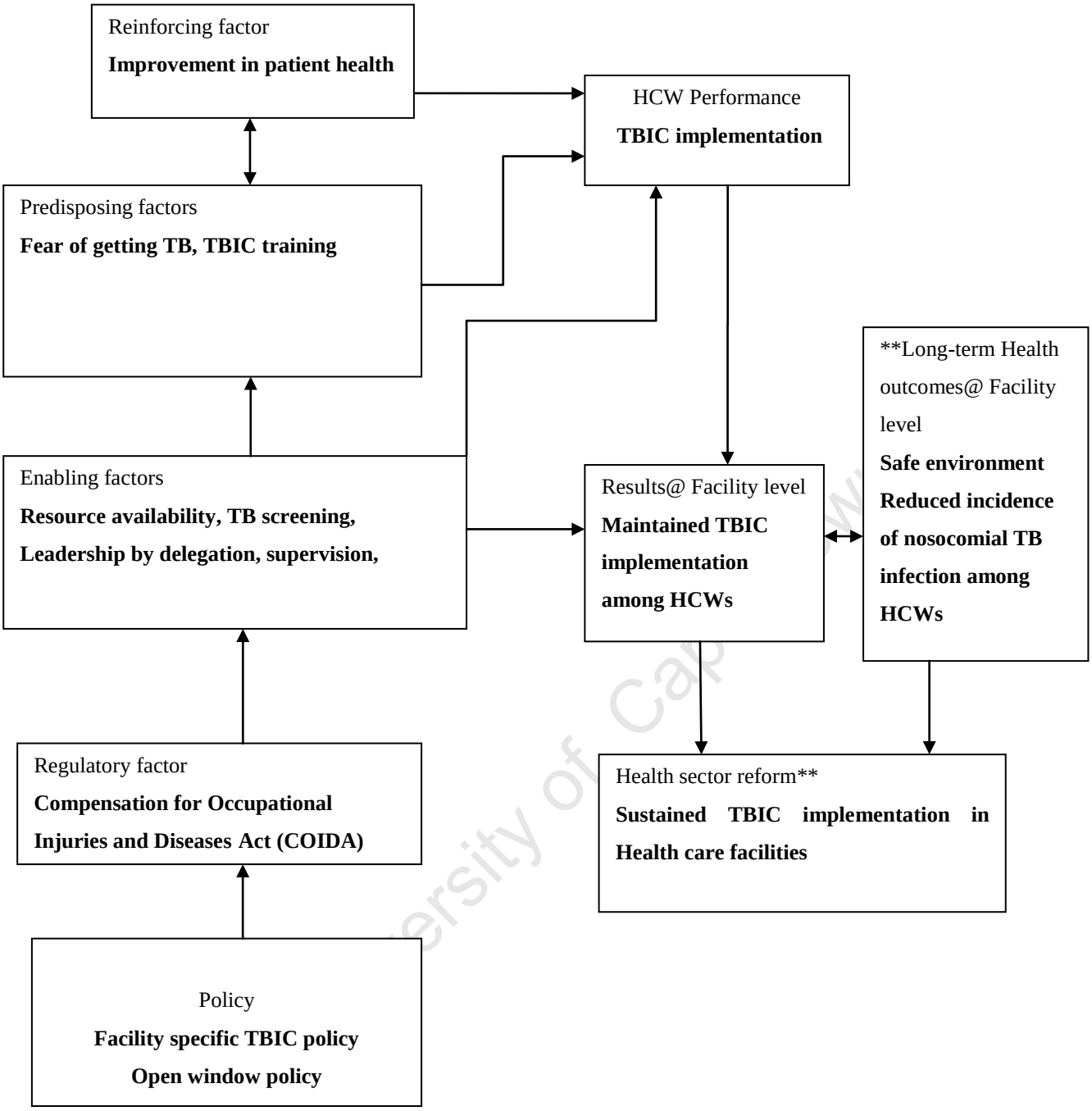

Figure 1: Motivation framework showing factors that influence TBIC implementation among HCWs Adapted from Work Motivation in the organisational context [24]) and Precede-Proceed model [38]

***Long term indicators not considered in the study*

Table 1: Summary of Direct Observation Grid

TBIC Code	Key TBIC Measure	Clinic A	Clinic B
A	No of patients in waiting areas/hallways	Moderate but crowded on some days	Mostly crowded but moderate on some days
A	Prompt identification/attendance reducing waiting hours	Prompt	Generally moderate but not consistent.
E	Opening of windows	Average. Poor compliance to open window policy on few occasions.	Very consistent. Windows always open
P	Use of N95 respirators(P)	Poor implementation. HCWs rarely used respirators	Moderate. Some HCWs occasionally do not wear respirators.
A	Use of paper masks(A)	Generally consistent	Consistent though patients remove masks when waiting for long hours.

Compiled by first author

Key*: A-Administrative control, E-Environmental control, P-Personal protective equipment*

Limitations

This study had several limitations. Purposive sampling of cases (clinics) may have introduced a form of selection bias. Bias was minimized by selecting multiple clinics and reporting enablers alongside barriers to TBIC practice. Key findings are based on HCWs' self-reported barriers to TBIC implementation and direct observation. However, collected data was compared with prior TBIC clinic assessment reports. Interpretation of qualitative data is often regarded as subjective. To minimize reporting bias, participants' responses were verified during report writing.

Another limitation was that interviews and FGDs were in English. Even though all HCWs could speak English, speaking a local language may have generated more data due to cultural affinity. However, a HCW assisted the researcher to interpret Xhosa phrases spoken by some lay HCWs during FGDs.

In addition, the conceptual framework on HCW motivation (Figure 1) did not consider long term indicators such as reduced incidence of health-care associated TB infection among HCWs and sustained TBIC implementation in health care facilities. This will require longer study period to observe daily implementation beyond a few working days. This study is applicable to other primary care clinics within Khayelitsha. This is because other primary care clinics within Khayelitsha have similar staff profile and comparable working conditions. Study findings can be relevant to Cape Town, South Africa at large because of they are governed by the same national health system. However no two clinics are exactly the same. Each clinic may differ in leadership style, HCW motivation and other contextual differences.

Finally, it is difficult to transfer case study research to other settings internationally (e.g other African countries) without considering the uniqueness of such setting such as health system.

Conclusion

Bureaucratic delay in compensating HCWs (with active TB disease) is a major barrier to building trust in the health system. Such mistrust is an obstacle to sustained TBIC implementation among HCWs. Professional and lay HCWs are not implementing TBIC in order of importance according to facility specific policy. The last line of defence PPE- was mostly prioritized by HCWs instead of administrative and environmental measures. TBIC is not likely to be effective in clinics where HCWs continue to prioritize PPE.

Protecting HCWs and patients from health-care associated infections is the sole responsibility of the health system. Professional and lay HCWs need to be trained (in-service) on TB transmission risk and how to implement TBIC to ensure effective TBIC implementation in clinics. Sub-district health systems should prioritize TBIC by training HCWs; continue to provide resources needed to implement TBIC and imbibe leadership by delegation with supervision in clinics. HCWs: an integral part of the health system ought to maximize resources provided and develop self-motivation needed to maintain TBIC implementation. Further research should focus on identifying behavioural models that further explain barriers to TBIC implementation among HCWs and how to address these barriers despite patient workload, insufficient HCWs and other resource constraints that characterise poor urban townships.

Bio

Oluwatoyin Adeleke

Oluwatoyin is studying for a Masters in Public Health at the University of Cape Town (UCT). She assumed the role of a relativist in this case study research seeking to understand and relate HCWs experiences (content) to the health care facility (context). Her passion lies in improving health systems for efficiency particularly among health workers.

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PART D: APPENDICES

LIST OF APPENDICES	
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Appendix 1.1: Semi- Structured Interview Guide for Professional HCWS

Health Facility: ……..
Name of Respondent: ……
Position/Designation: ……..
Age: Sex: Male/Female
Level of education:
Years/months worked at facility:
Services provided in this facility (Tick appropriately)
□ Integrated TB-HIV Services □ TB services
□ VCT/ART services □ In-Patient Services

1. Are you aware of any TBIC activity being implemented in this facility?
   Probe: When did it start?
2. How is it being implemented?
   Probe: Any IC plan in place?
3. What is your role in TBIC implementation in this facility?
4. Have you ever been trained on TBIC? (*Give details of the training – content, duration, by whom and when)*
5. How do you find daily implementation of this role as a HCW?
   Probe on perceived role in administrative, environmental and personal protection IC measures
6. What motivates or de-motivates you in carrying out such roles? *(motivate/de-motivate could be an incentive, financial or non-financial/ anything that encourages or discourages HCWs)*
7. Any challenges faced in implementing TBIC administrative, environmental or personal protection measures? *(Interviewer is to list examples under each TBIC measure but do NOT lead respondents).*
8. What support does the 'facility' (health system) provide to assist HCWs to implement TBIC measures? (Support in form of resources, do NOT lead respondent(s)
9. What are some of the barriers to implementation? *Probe: Categorize respondent(s) responses to health system barriers per TBIC measure (administrative, environmental and personal protection) and probe further.*
10. What are some of the enablers to TBIC implementation (*Filter question for Number 6, check the coherence in question 9 and 10 and clarify with respondent if any discrepancy exists).*
11. Can you suggest ways to overcome these barriers and improve HCWS performance in TBIC implementation?

Thank You for your time!

Appendix 1.2: Key informant Interview Guide for Head of Clinic or Management staff

Health Facility: ……..
Name of Respondent: ……
Position/Designation: ……..
Age: Sex: Male/Female
Level of education:
Years/months worked at facility:
Services provided in this facility (Tick appropriately)
□ Integrated TB-HIV Services □ TB services
□ VCT/ART services □ In-Patient Services

1. Are you aware of any TBIC activity being implemented in this facility?
   Probe: When did it start? Who is responsible for implementation? Who monitors to ensure implementation?
2. How is it being implemented?
   Probe: Any IC plan in place? Has any IC committee established in health facility? (If yes) How often do they meet?
3. Has an IC assessment been done since it started?
   Probe: Who did the assessment and were you informed about results of such assessment?
4. What is your role in TBIC implementation in this facility?
   Probe on perceived role in administrative, environmental and personal protection IC measures
5. Have you ever been trained/trained HCWs on TBIC? (*Give details of the training – content, duration, by whom and when)*
6. What do you think motivates or de-motivates HCWs in implementing TBIC in clinics? *(motivate/de-motivate could be an incentive, financial or non-financial/ anything that encourages or discourages HCWs)*
7. What support does the 'facility' (health system) provide to assist HCWs to implement TBIC measures? (Support in form of resources, do NOT lead respondent(s)
8. What are some of the barriers to implementation? *Probe: Categorize respondent(s) responses to health system barriers per TBIC measure (administrative, environmental and personal protection) and probe further.*
9. What are some of the enablers to TBIC implementation (*Filter question for Number 6, check the coherence in question 9 and 10 and clarify with respondent if any discrepancy exists).*
10. Can you suggest ways to overcome these barriers and improve HCWS performance in TBIC implementation?

Thank You for your time!

Appendix 1.3: Focus Group Discussion Guide for Lay HCWs

Health Facility: ……..
Name of Respondent: ……
Position/Designation: ……..
Age: Sex: Male/Female
Level of education:
Years/months worked at facility:
Services provided in this facility (Tick appropriately)
□ Integrated TB-HIV Services □ TB services
□ VCT/ART services □ In-Patient Services

Ice Breaker: Share with us one of the things you enjoy doing (hobby).

1. Are you aware of any activity to prevent TB being implemented in this facility?
   Probe: When did it start?
2. How is it being implemented?
3. What is your role in preventing TB in this facility?

Probe: on specific role…cough monitor, cleaning sputum booths, opening windows….

4. Have you ever been trained on how to carry out these roles (mentioned in Q3)? (*Give details of the training – content, duration, by whom and when)*
5. How do you find daily implementation of this role as a HCW?
   Probe on perceived role in administrative, environmental and personal protection IC measures (Use Probe in Q3)
6. What encourages or discourages you to/from i carrying out such roles? *(motivate/de-motivate could be an incentive, financial or non-financial/ anything that encourages or discourages HCWs)*
7. Any challenges faced in implementing TBIC administrative, environmental or personal protection measures? *(Interviewer is to list examples under each TBIC measure but do NOT lead respondents).*
8. What support does the 'facility' (health system) provide to assist you to implement TBIC measures? (Support in form of resources, do NOT lead respondent(s)
9. What usually stops you from carrying out these roles? *Probe: Categorize respondent(s) responses to health system barriers per TBIC measure (administrative, environmental and personal protection) and probe further.*
10. What usually helps you carry out your roles (*Filter question for Number 6, check the coherence in Q 9 and 10 and clarify with respondent if any discrepancy exists).*
11. Can you suggest ways to overcome these barriers (mentioned in 9) and improve your performance in TBIC implementation?

Thank You for your time!

Appendix 2.0: Direct Observation Grid

Health Facility/Clinic: ……..

Services provided in this facility (Tick appropriately)

□ Integrated TB-HIV Services □ TB services

□ VCT/ART services □ In-Patient Services

Record time observation starts……

Record time observation ends……

General Comments on clinic environment: *(Cleanliness, size, patient load at time of observation, observable bureaucracy in HCW/Patient interaction)*

For each observation, give observed reason for 'Y' or 'N' under 'comment'

Code	Activity being Observed (Y/N)	Comment
E	Are patients are crowded in hall ways or waiting areas?	
A	Are patients promptly identified in waiting areas or as soon as they enter clinic?	
A	Are coughing patients promptly attended to by HCWs? *(Note how long it took before attending to patient)*	
P	Do HCWs who interact with patients wear respirators? *(If not, any observable reasons why)*	
P	Do HCWs remove respirators sometimes? *(Note observable reasons)*	
A	Did you observe HCW(s) distributing paper masks to patients? *(Any shortage observed)*	
A	Do patients comply with use of masks or was it removed at any point in time? *(Note observable reasons)*	
A	Are sputum booths available? *(Located in clinic waiting room area/ outside waiting room area within premises/ outside premises)*	
A	Are sputum samples collected in designated booths? *(observe sputum booths and comment)*	
E	Are windows opened at all times? *(In waiting areas, consultation rooms…)*	
E	Whirly Bird installed? *(Comment on observable maintenance culture of HCW)*	
Observe and comment on behaviour of HCWs in carrying out above TBIC practices and interaction with patients (Note motivation (enablers) and de-motivation (barriers) to implementation).		

CODE: 'A' Administrative control, 'E' Environmental control, 'P' Personal protection, 'Y' Yes, 'N' No

Appendix 3.0: Participant Information sheet and Consent Form

Research Title: Health systems barriers to sustained implementation of Tuberculosis Infection control (TBIC) among Health Care Workers (HCWs) in Khayelitsha Clinics

Introduction
My name is Toyin Adeleke, I am a student at the University of Cape Town doing research in your health facility as part of the requirements needed to complete my Masters in Public Health programme.

Purpose of Study
Infection control is a way of protecting the health of staff and patients in clinics. The purpose of this study is to find out if there is anything preventing TB infection control from working well in your clinic. This research is not a **monitoring exercise and will not check up on how well individual health care workers are doing.** Instead, I want to understand how you operate on a daily basis and I want to identify the challenges you are having in carrying out your duties. I will observe infection control practices so I can make suggestions that will benefit you and other staff.

Methods
I will be collecting information either from each person (interview) or in groups (focus group discussion). Focus group discussion includes a group of individuals that share similar characteristics. For this research, staff with the same job description will be in the same group. I would like to use a tape recorder with your permission. All the tapes of our discussions will be destroyed after these have been put into typed notes. I will also be observing some of your daily activities in the clinic. This observation is also not to monitor your performance; I only want to observe challenges you may encounter while performing your duties.

Other participants
Apart from you, other health care workers such as doctors, nursing attendants, facility managers, and cleaners who work in this clinic will also be asked to participate in this research voluntarily (by choice).

Procedures
Participation in interviews and group discussions for this study is voluntary; I have taken permission from your facility manager to allow you participate in this interview/discussion during working hours. You will be asked some questions either alone or in groups. Interviews will last for 30mins and group discussion will last for about an hour. Food will be served during the interviews and discussion. You may stop participating in the study at any point during the interview or choose not to answer a particular question. Participating or not participating will not affect your job at the clinic in any way.

Confidentiality
Your responses and information provided during this interview or discussions are confidential. Your name will not be linked to your responses as you will be identified only by a study number. If you participate in a group discussion, you may discuss issues raised during the session with people outside of the group, but I will like you to maintain the confidentiality of what was discussed in the group and the identity of the participants. The identity of your clinic will be protected by not mentioning its name in the report if you choose. As I mentioned earlier, all the tapes of our recorded discussions will be destroyed after these have been put into typed notes.

Potential risks or interruption

We understand how busy it gets attending to patients in your clinic. In the course of the interview or discussion, if you need to attend to your duties, please feel free to inform the researcher so you may be excused.

Please tick '√' in the boxes below:

I confirm that I have read and understand the information sheet dated ..... for the above study □

I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. □

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected. □

I grant permission to the researcher to audio record interviews / group discussion as long as tape is destroyed after recorded data have been typed into notes. □

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Name of researcher	Date	Signature

Identification of researcher

If you have any questions about the research, please contact: 'Toyin Adeleke 0712792700 Oluwatoyin.Adeleke@uct.ac.za

Right of research subjects

If you have questions regarding your rights as a research subject, contact the Research Office at the Faculty of Health Sciences at the University of Cape Town on 021 650 4015.

Appendix 4.1

The Ideal: WHO recommended measures for facility-level TB infection control (WHO, 2009)

The measures listed below are specific to health-care facilities.

Facility-level measures

- Implement the set of facility-level managerial activities:
- Identify and strengthen local coordinating bodies for TB infection control, and develop a facility plan (including human resources, and policies and procedures to ensure proper implementation of the controls listed below) for implementation.
- Rethink the use of available spaces and consider renovation of existing facilities or construction of new ones to optimize implementation of controls.
- Conduct on-site surveillance of TB disease among health workers and assess the facility.
- Address advocacy, communication and social mobilization (ACSM) for health workers, patients and visitors. Monitor and evaluate the set of TB infection control measures. Participate in research efforts.

Administrative controls

- Promptly identify people with TB symptoms (triage), separate infectious patients, control the spread of pathogens (cough etiquette and respiratory hygiene) and minimize time spent in health-care facilities.
- Provide a package of prevention and care interventions for health workers, including HIV prevention, antiretroviral therapy and isoniazid preventive therapy (IPT) for HIV-positive health workers.

Environmental controls

- Use ventilation systems.
- Use ultraviolet germicidal irradiation (UVGI) fixtures, at least when adequate ventilation cannot be achieved.

Personal protective equipment

- Use particulate respirators.

Appendix 4.2

Reality: Infection control measures implemented in Khayelitsha health care facilities (HATIP, 2010, MSF 2011)

Administrative controls

- Establishment of infection control committees in each facility
- Ongoing staff training
- Education in cough hygiene/Identification of coughing patients
- Routine screening of health workers and adjustment to patient flow to reduce overcrowding
- Paper masks provided to all clinic attendees in reception and waiting rooms.

Environmental controls

- Improving natural ventilation(opening windows and doors leading outside)
- IEC materials such as Stop TB stickers placed on all windows
- Wind-driven air extractor turbines(whirlybirds) installed in indoor waiting areas, corridors and consultation rooms to increase natural ventilation
- Wall or door grates installed to increase air-flow if windows are closed during winter months
- Outdoor waiting areas used (where feasible)
- Well –ventilated sputum collection booths outdoors provided in all facilities

Personal Protection

- Use of N95 respirators by all clinic staff encouraged

Appendix 5.1: UCT Human Research Ethics approval

UNIVERSITY OF CAPE TOWN

Faculty of Health Sciences
Faculty of Health Sciences Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
e-mail: sumayah.ariefdien@uct.ac.za

05 December 2011

HREC REF: 506/2011

Ms O Adeleke
c/o Dr A Rother
Public Health & Family Medicine
Falmouth Building

Dear Dr Rother

PROJECT TITLE: HEALTH SYSTEMS BARRIERS TO SUSTAINED IMPLEMENTATION OF TB INFECTION CONTROL AMONG HEALTH CARE WORKERS IN KHAYELITSHA HEALTH CARE FACILITIES

Thank you for addressing the issues raised by the HREC.

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Approval is granted for one year till the 15 December 2012.

Please submit a progress form, using the standardised Annual Report Form (FHS016), if the study continues beyond the approval period. Please submit a Standard Closure form (FHS010)if the study is completed within the approval period.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

sAriefdien

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

sAriefdien

Appendix 5.2: City Health Ethics Approval

Civic Centre
12 Hertzog Boulevard
Cape Town 8001
P O Box 2815, Cape Town 8000
Ask for: Dr G H Visser
Tel: 021 400-3961
Cell: 083 298 8718
Fax: 021 421-4894

Iziko loLuntu
12 Hertzog Boulevard
Cape Town 8001
P O Box 2815, Cape Town 8000
Cela: Qrh G H Visser
Umnxeba: 021 400-3981
Cell: 083 298 8718
Ifeksi: 021 421-4894

Burgersentrum
Hertzog-boulevard 12
Kaapstad 8001
Posbus 2815, Kaapstad 8000
Vra vir: Dr G H Visser
Tel: 021 400-3981
Sel: 083 298 8718
Faks: 021 421-4894

E-mail: helene.visser@capetown.gov.za
Website: http://www.capetown.gov.za
Ref:
Filename: G:\Research\2012\OAdeleke10282.docx

CITY HEALTH — Specialised Health

2012-03-02

re: Research Request: Health systems barriers to sustained implementation of TB infection control among Health Care workers in Khayelitsha health care facilities (ID NO: 10282)

Dear Ms Adeleke

Permission has been granted to do your research as per your protocol.

Khayelitsha Sub District:	**Town 2 CHC and Kuyasa Clinic**
Contact People	Dr V de Azevedo (Sub District Manager) Tel: (021) 360-1258/ 083 629 3344 Mr T Mhlubulwana (Head: PHC & Programmes) Tel: (021) 360-1153/ 082 715 0147

Please note the following:

1. All individual patient information obtained must be kept confidential.
2. Access to the clinics and its patients must be arranged with the relevant Managers such that normal activities are not disrupted.
3. A copy of the final report must be sent to the City Health Head Office, P O Box 2815 Cape Town 8001, within 3 months of its completion and feedback must also be given to the clinics involved.
4. Your project has been given an ID Number (10282). Please use this in any future correspondence with us.

Thank you for your co-operation and please contact me if you require any further information or assistance.

Yours sincerely

pp DR VISSER

DR G H VISSER
MANAGER: SPECIALISED HEALTH

cc. Dr Azevedo & Mr Mhlubulwana
Dr K Jennings
Ms Caldwell

Appendix 6.0

Guidelines for Standard Sections- PLOS ONE

Title

Manuscripts must be submitted with both a full title and a short title, which will appear at the top of the PDF upon publication if accepted. Only the full title should be included in the manuscript file; the short title will be entered during the online submission process.

The full title must be 150 characters or fewer. It should be specific, descriptive, concise, and comprehensible to readers outside the subject field. Avoid specialist abbreviations if possible. Where appropriate, authors should include the species or model system used (for biological papers) or type of study design (for clinical papers).

Examples:

- Impact of Cigarette Smoke Exposure on Innate Immunity: A *Caenorhabditis elegans* Model
- Solar Drinking Water Disinfection (SODIS) to Reduce Childhood Diarrhoea in Rural Bolivia: A Cluster-Randomized, Controlled Trial

The short title must be 50 characters or fewer and should state the topic of the paper.

Authors and Affiliations

All author names should be listed in the following order:

- First names (or initials, if used),
- Middle names (or initials, if used), and
- Last names (surname, family name)

Each author should list an associated department, university, or organizational affiliation and its location, including city, state/province (if applicable), and country. If the article has been submitted on behalf of a consortium, all author names and affiliations should be listed at the end of the article.

This information cannot be changed after initial submission, so please ensure that it is correct.

PLOS ONE bases its criteria for authorship on those outlined by the International Committee of Medical Journal Editors (ICMJE), summarized below:

Authors should meet conditions 1, 2, and 3 below to be assigned credit for authorship:

1. substantial contributions to conception and design of the work, acquisition of data, or analysis and interpretation of data
2. drafting the article or revising it critically for important intellectual content; and
3. final approval of the version to be published.

All persons designated as authors should qualify for authorship, and all those who qualify should be listed.

When a large, multicenter group has conducted the work, the group should identify the individuals who accept direct responsibility for the manuscript. These individuals should fully meet the criteria for authorship/contributorship defined above. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

When submitting a manuscript authored by a group, the corresponding author should clearly indicate the preferred citation and identify all individual authors as well as the group name. The contributions of all authors must be described. Note that acquisition of funding, collection of data, or general supervision of the research group alone does not constitute authorship. Contributions that fall short of authorship should be mentioned in the Acknowledgments section of the paper.

The National Library of Medicine (NLM) indexes the group name and the names of individuals the group has identified as being directly responsible for the manuscript. The NLM also lists the names of collaborators if they are listed in Acknowledgments**.**

One author should be designated as the corresponding author, and his or her email address or other contact information should be included on the manuscript cover page. This information will be published with the article if accepted.

Abstract

The abstract should not exceed 300 words. It should:

- Describe the main objective(s) of the study
- Explain how the study was done, including any model organisms used, without methodological detail
- Summarize the most important results and their significance

Abstracts should not include:

- Citations
- Specialist abbreviations, if possible

Introduction

The introduction should:

- Provide some background to put the manuscript into context and allow readers outside the field to understand the purpose and significance of the study
- Define the problem addressed and why it is important
- Include a brief review of the key literature
- Note any relevant controversies or disagreements in the field
- Conclude with a brief statement of the overall aim of the work and a comment about whether that aim was achieved

Materials and Methods

This section should provide enough detail to allow suitably skilled investigators to fully replicate your study. Specific information and/or protocols for new methods should be included in detail. If materials, methods, and protocols are well established, authors may refer to other papers where those

protocols are described in detail, but the submission should include sufficient information to be understood independent of these references.

We encourage authors to submit detailed protocols for newer or less well-established methods as Supporting Information. These are published online only, but are linked to the article and are fully searchable. For more information about formatting Supporting Information files, click here.

Methods sections of papers on research using **human or animal subjects and/or tissue or field sampling** must include required ethics statements. See the Reporting Guidelines for human research, clinical trials, animal research, and observational and field studies for more information.

Methods sections of papers with **data that should be deposited in a publicly available database** should specify where the data have been deposited and provide the relevant accession numbers and version numbers, if appropriate. Accession numbers should be provided in parentheses after the entity on first use. If the accession numbers have not yet been obtained at the time of submission, please state that they will be provided during review. They must be provided prior to publication.

Methods sections of papers using **cell lines** must state the origin of the cell lines used. See the Reporting Guidelines for cell line research for more information.

Methods sections of papers adding **new taxon names** to the literature must follow the Reporting Guidelines below for a new zoological taxon, botanical taxon, or fungal taxon.

Results, Discussion, and Conclusions

These sections may all be separate, or may be combined to create a mixed Results/Discussion section (commonly labeled "Results and Discussion") or a mixed Discussion/Conclusions section (commonly labeled "Discussion"). These sections may be further divided into subsections, each with a concise subheading, as appropriate. These sections have no word limit, but the language should be clear and concise.

Together, these sections should describe the results of the experiments, the interpretation of these results, and the conclusions that can be drawn. Authors should explain how the results relate to the hypothesis presented as the basis of the study and provide a succinct explanation of the implications of the findings, particularly in relation to previous related studies and potential future directions for research.

PLOS ONE editorial decisions do not rely on the novelty or perceived impact, so authors should avoid overstating their conclusions. See the *PLOS ONE* Publication Criteria for more information.

Acknowledgements

People who contributed to the work but do not fit the *PLOS ONE* authorship criteria should be listed in the acknowledgments, along with their contributions. You must ensure that anyone named in the acknowledgments agrees to being so named.

Funding sources should **not** be included in the acknowledgments, or anywhere in the manuscript file. You will provide this information during the manuscript submission process.

References

Only published or accepted manuscripts should be included in the reference list. Papers that have been submitted but not yet accepted should not be cited. Limited citation of unpublished work should be included in the body of the text only as "unpublished data." All "personal communications" citations should be supported by a letter from the relevant authors.

Style information:

- PLOS uses the numbered citation (citation-sequence) method and first five authors, et al.
- References are listed and numbered in the order that they appear in the text.
- In the text, citations should be indicated by the reference number in brackets.
- The parts of the manuscript should be in the correct order *before* ordering the citations: body, boxes, figure captions, tables, and supporting information captions.
- Abstracts and author summaries may not contain citations.
- Journal name abbreviations should be those found in the NCBI databases: http://www.ncbi.nlm.nih.gov/nlmcatalog/journals.

Because all references will be linked electronically as much as possible to the papers they cite, proper formatting of the references is crucial. For convenience, a number of reference software companies supply PLOS style files (e.g., Reference Manager, EndNote).

Published Papers
1. Hou WR, Hou YL, Wu GF, Song Y, Su XL, et al. (2011) cDNA, genomic sequence cloning and overexpression of ribosomal protein gene L9 (rpL9) of the giant panda (*Ailuropoda melanoleuca*). Genet Mol Res 10: 1576-1588.

Note: Use of a DOI number for the full-text article is acceptable as an alternative to or in addition to traditional volume and page numbers.

Accepted, unpublished papers
Same as above, but "In press" appears instead of the page numbers.

Electronic Journal Articles
1. Huynen MMTE, Martens P, Hilderlink HBM (2005) The health impacts of globalisation: a conceptual framework. Global Health 1: 14. Available: http://www.globalizationandhealth.com/content/1/1/14. Accessed 25 January 2012.

Books
1. Bates B (1992) Bargaining for life: A social history of tuberculosis. Philadelphia: University of Pennsylvania Press. 435 p.

Book Chapters
1. Hansen B (1991) New York City epidemics and history for the public. In: Harden VA, Risse GB, editors. AIDS and the historian. Bethesda: National Institutes of Health. pp. 21-28.

Figure legends

Figures should **not** be included in the manuscript file, but figure legends should be.

Figure legends should describe the key messages of a figure. Legends should have a short title of 15 words or less. The full legend should have a description of the figure and allow readers to understand

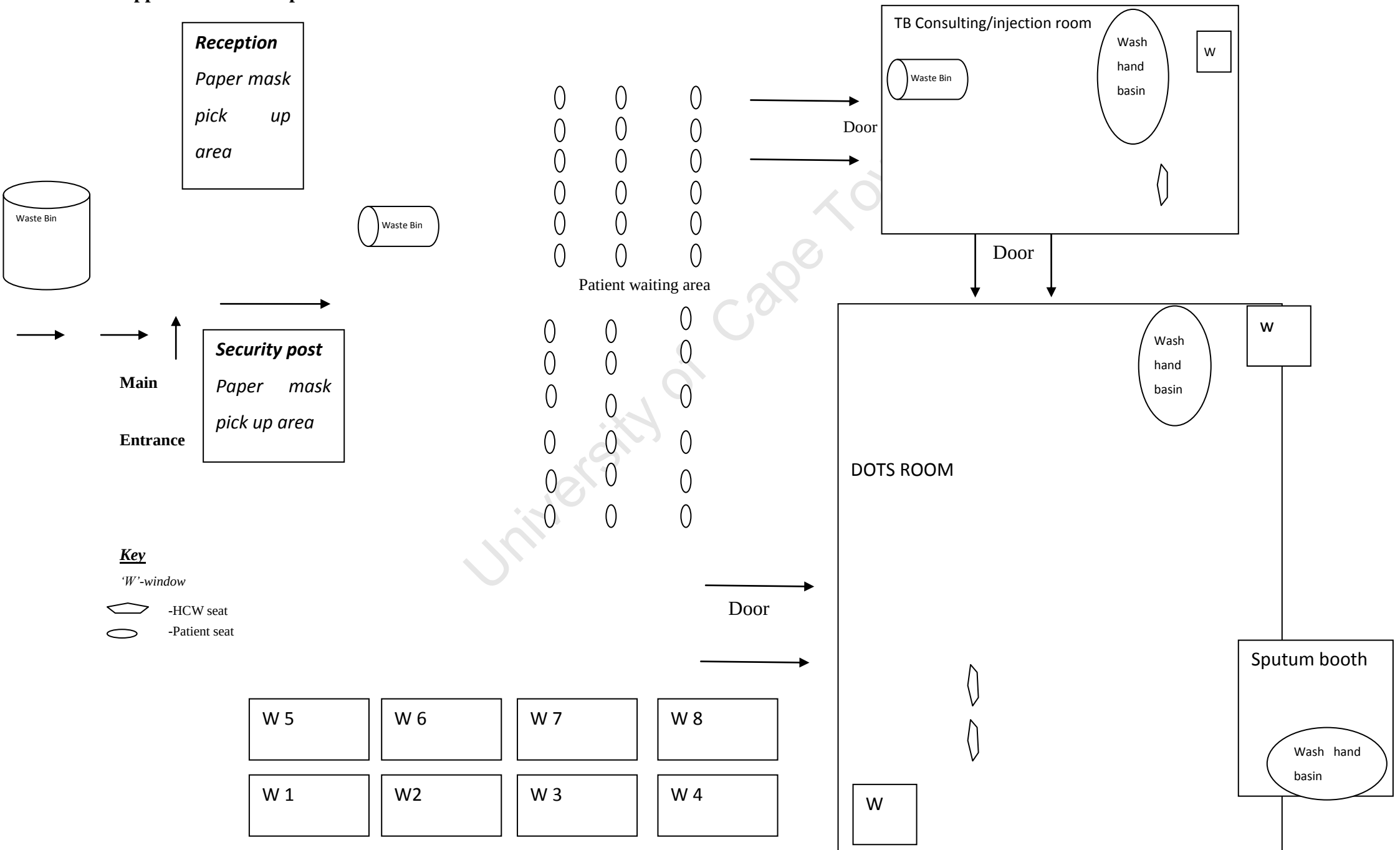
the figure without referring to the text. The legend itself should be succinct, avoid lengthy descriptions of methods, and define all non-standard symbols and abbreviations.

Further information can be found in the Figure Guidelines.

Tables

Tables should be included at the end of the manuscript. All tables should have a concise title. Footnotes can be used to explain abbreviations. Citations should be indicated using the same style as outlined above. Tables occupying more than one printed page should be avoided, if possible. Larger tables can be published as Supporting Information. Please ensure that table formatting conforms to our Guidelines for table preparation.

Appendix 7.1 Floor plan TB section –Clinic A



Appendix 7.2 Floor plan TB section-Clinic B